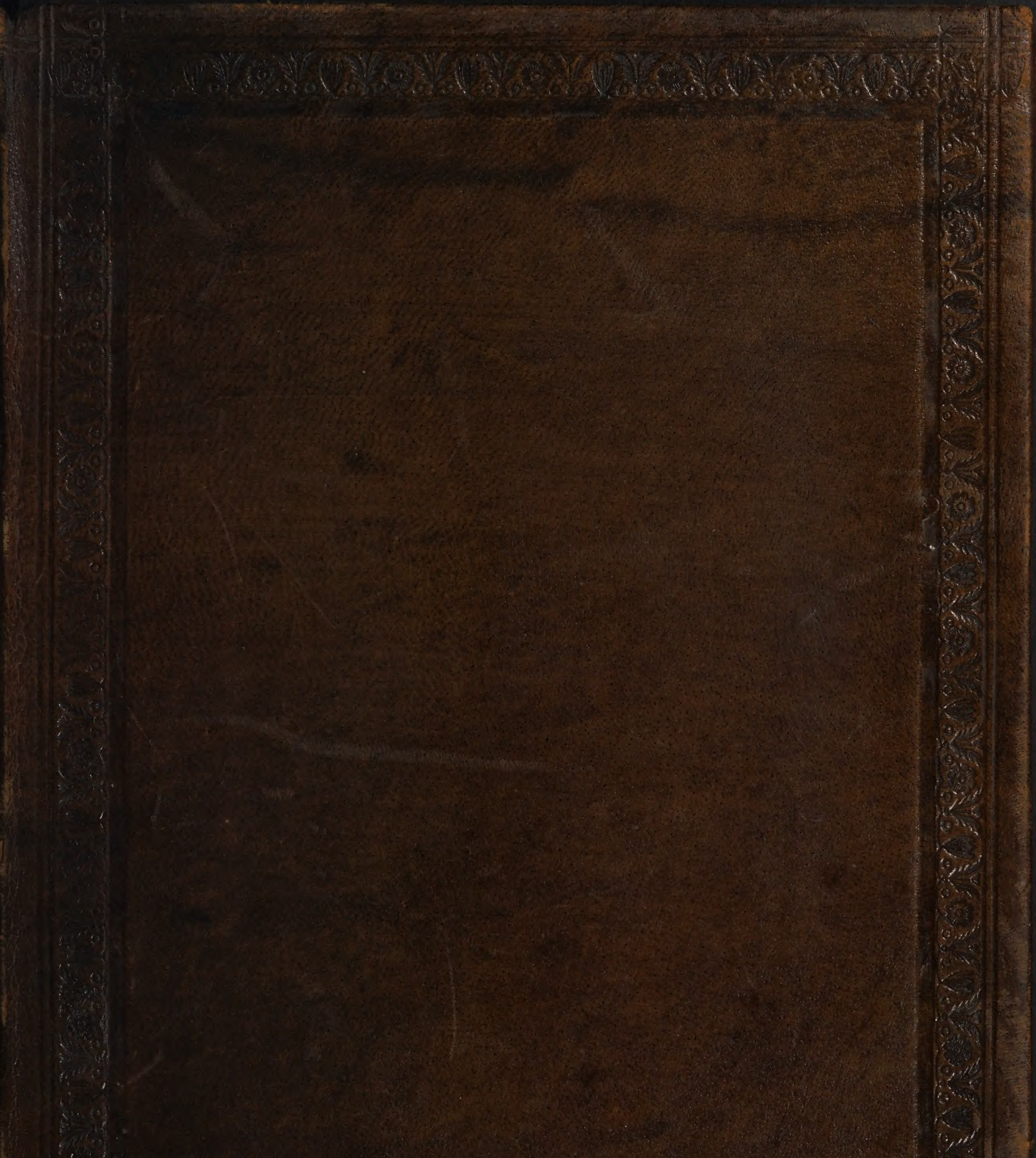


FALE — HOROLOGIOGRAPHIA

2146

3122

Horologiographia.
THE ART OF DIALLING:

Teaching, an Eaſie and Perfect
Way to make all Kindes of
DIALS
Vpon any plain Plat howſoever placed.
With the drawing of the Twelve Signes, and
Howres unequall in them all.
whereunto is annexed the making and uſe of other
*Dials and Inſtruments, whereby the houre of the day
and Night is knowne:*
Of ſpeciall uſe and delight, not onely for Students of the Arts
Mathematicall, but alſo for divers Artificers, Architects,
Surveyers of Buildings, free-Maſons and others.

By Thomas Fale.

y KINGSTO

(1593)

To the friendly Readers, and namely, to ſuch as be well-willers to the *Mathematicks.*

THe Arts Mathematicall (gentle Reader) in regard of their antiquity and excellence (may be compared with any other of the liberall Sciences whatſoever. For *Seth*, who lived in the firſt age of the world, is commended of *Ioſephus*, and *Abraham* of *Beroſus*, to have beene skilfull maſters in theſe miſteries. And the very name importeth that in old time theſe of all other were eſteemed worthy to bee taught, being called for their excellency *Mathemata*, that is, Sciences meet to be learned. Theſe be *Arithmetike*, *Geometry* and *Aſtronomy*, from which this Art of Dialling taketh his beginning: a knowledg alſo ancient and neceſſary, and therefore practiſed by Princes and famous men of former Ages. The firſt Diall that hiſtories remember, is *Lib.2.chap.* 20. of the Kings in the holy Scripture, where the Lord turned the Sunne back 10. degrees for *Hezekias* ſake, whereby it had gone down in the Diall of *Ahaz*. This *Ahaz* was king of *Ieruſalem*, and reigned in the 3200. yeere after the creation of the World, and in the firſt Olimpiade of the Grecians, Afterward, as *Plinie* writeth, *Anaximenes Mileſius* the ſcholler of *Anaximander*, firſt found out the reaſon and proportion of ſhadowes amongſt the Lacedemonians, and there taught the Art of Dialling, who lived 200. yeere after the raigne of *Ahaz*, and was a famous Philoſopher in *Greece* before *Platoes* time, as *Diogenes Laertius* reporteth. But ſome affirme that it was *Anaximander* himſelfe that found out this Art, and ſet forth the firſt Mappe of the Earth.

Lib.2. *Herodotus* ſaith that the Grecians learned this art, and the diviſion of the day in 12 houres, of the Chaldeans. *Diodorus* writeth that one *Hyperion* firſt obſerved the houres. But if wee may beleeve *Macrobius*, it ſeemeth that this Science came from the Egyptians for they called the Sun *Horus* which by his motion limiteth to each houre his appointed time.

Lib.9. *Vitruvius* rehearſeth ſundry inventors of this art of Dialling, as *Beroſus* the Caldean, *Ariſtarchus*, *Samius*, *Eudoxus* *Theodoſus* with others who were renowned, and lived many yeeres before the birth of Chriſt, I need not here remember *Architas Tarentinus*, who by art made a Dove of wood to fly in the ayre: neither *Archimedes*, who defended *Syracuſa* againſt *Marcellus*, and affirmed that if he had a place to ſtand on, he would move the earth with his engines: both of them no doubt skilfull in this Science. Plutarch.in Marcel.

It was long after the invention that this Art was known in *Rome*: for in the 12. tables was only mentioned the riſing and ſetting of the *Sun*, and after certain yeeres the mid day was added. Then in the firſt *Punike war* the *Romanes* obtaining victory, there was a Diall brought forth among other ſpoyles out of *Sicily*. But in proceſſe of time they began to be more common in *Rome*: for 100 yeeres before *Ciceroes* time, the paraſite in a Commedy, being hungry ſpake againſt the multitude of Clocks and Dialls which were then in the City, *Optans ut ſuus cuique venter ſit horologium.*

Lib.36.c.10. *Plinie* alſo telleth of a Diall placed in the field of *Flora* at *Rome*, which by the ſpace of 30 yeeres had not ageeed with the Sun; & the reaſon was as he thought, becauſe that either the Sun had taken a new courſe, or elſe the earth was ſlipped from his Centre, wherein at the firſt it ſtood, or the ſtile was put a wry by the ſhaking of the city. Since which times learning ſpreading it ſelfe into divers parts of the world, this Art hath beene amongſt the reſt in great account.

Concerning the profit of this Art, daily experience teacheth, how needfull it is in a well ordered Common-wealth, ſeeing nothing can be done in due and convenient ſeaſon, where this Science is neglected: for the diviſion of the day into certain parts or houres (which this Art teacheth) doth limit and allot to each action his due time. This Art being then ſo ancient, and the uſe ſo neceſſary, I truſt none will thinke this labour ſuperfluous, unleſſe they be rude without civility, or ſuch as have alwayes at hand a Diall of natures framing, of whom this verſ ſeemeth to be made :

Morus.

Si tuus ad ſolem ſtatuatuo naſus hianti
Ore, bene oſtendas dentibus hora quota eſt.

Many have promiſed (but none as yet performed) to write of this Science in our Engliſh tongue, which had been publiſhed in other Languages, as *D. Record* long ſince, *M. Digs, M. Blagrave* with other, who if they would take the paines, I know could doe it with great commendation

Divers have written hereof in the Latine tongue, as *Munſter, Schonerus, Orontius, Witekendus, Clavius* and others : yet every one differing from other in precept. Some teach the making of Dialls by the helpe of the Globe, as *Gemma Friſius* : ſome by the Aſtrolabe, as the ſame *Gemma Friſius* and *M. Blagr.* which inſtruments every man have not. Some uſe the table of *Sines* and *Arithmetick*, as *Witekendus*, which way as moſt plain & eaſie, is obſerved in this booke, though in ſome kindes for want of triall *Witekendus* deceived himſelfe. *Munſter* uſeth a *Rectificatory* with a circle, which is unfit for ſmall plats, and faileth in greater, without great heede. *Schoner* wandreth in a wilderneſſe of lines, that a man knowes not where to begin, or when to end. *Vlmer* hath not the Delineation of all kindes.

Otherſome obſerve the rules of Geometricall proportion which order alſo we thought to have obſerved in all kindes, as we have done in the South & North erect declining, but that ſundry precepts of the ſame thing would have bred tediouſnes and trouble to the learner, and the cutting of the Figures would have bin very chargeable. By meanes whereof we contented our ſelves with this one way here ſet downe, not donbting, but that every one with ſmall paines may attaine to the making of all kindes of Dials in this booke expreſſed. As for a great part of them, every Artificer may eaſily underſtand.

Onely thus much I advertiſe the unlearned, that they muſt acquaint themſelves with ſome few Mathematicall principles, as to know what the Elevation of the Pole meaneth, how a ſquire line is to bee drawn, and ſuch like, which (if they want a teacher) they may ſufficiently learn by themſelves out of *Records Caſtle*, his pathway and ground of Artes, publiſhed in the Engliſh tongue : for theſe tearmes could not be avoided, neither plainely deſcribed without much tediouſneſſe.

Wee have here added alſo Examples and Figures to every kinde, that ſo the precepts might appeare more plaine and eaſie : ſo that there is no plain plat or wall, howſoever it ſtandeth, or be placed either Declining, Reclining or Inclining but by the helpe of this booke you may draw a Diall upon it.

If any man complaine of obſcurity, hee muſt know, that *Difficilia quæ pulchra*, and yet ſmall paines overcommeth all.

The making of the Horologicall Cylindre, and the Ring with ſome other inſtruments, we have preſently omitted, partly for their curioſity in cutting and delineation, and partly becauſe (if occaſion ſerve) we will entreat of theſe kindes of Horologicall inſtruments by themſelves, together with the making of all kindes of plaine Dialls in this booke, preſcribed by the way of Geometricall proportion.

In the meane while (gentle Reader) committing
this booke to thy favourable acceptation,
and thy ſelfe to the protection of
the Almighty, I end.

THOMAS FALE.

To my loving kinſman *Tho. Osborne.*

THis Book, which ſeven yeers ſince was in a manner perfected (as you know) doth now upō iuſt occaſion preſent it ſelfe to the view of the world: wherein you have takē ſuch pains for the triall of each example, that I think none can finde any great fault, but ſuch as can ſee farr into other mens faults, & forget their owne. For after we found ſome precepts in Witekindus *to be falſe, we were enforced to try and examine with great care each figure and example in the Sun. And therefore if any receive benefit by this our triall, I would you ſhould have your due praiſe you deſerv. I have altered ſome few things, & added the making of the South & North Erect declining Dials, by the way of Geometricall proportion: becauſe thoſe kindes be moſt in uſe, and I would the learner ſhould have his choiſe of the eaſieſt way.*

The graver of the Figures *was one* M. Iod. Hondius *who hath ſhewed himſelfe an excellent workeman in the great Globes ſet forth by* M. Mullineux, *and the Maps of England for* M. Camdens *booke: and whether he hath performed like diligence in theſe I referr it to your ſelf to iudge. If any be deſirous to have the inſtaument mentioned in the beginning of this booke, for the tryall of plats, I hope you will helpe them to it: for being of your owne invention, I know none ſo fit as your ſelfe to make it: on which inſtrument alſo, it were convenient to draw the quadrant Horologicall that ſo it might ſerve for divers uſes.*

I truſt you wil not be offended, in that I leave under our names this ſmal monument unto the world, as a ſpeaking witneſſe of our thankfull hearts to this our Country, and a teſtimony of our affection towards the Arts Mathematicall. Thus beſeeching the Lord (who hath endued you with extraordinary knoledge in all Manuall Sciences) to finiſh that good worke of his heavenly grace already begun in you, to his glory and your owne comfort I take my leave. Commend me many times to your ſelfe, and all our good friends. From London, *Ianuary 3. 1593.*

Yours aſſuredly, *T. F.*

Advertiſemens to

the Reader.

NOte alwaies that in every Diall the one end of the Stile muſt bee placed directly towards the North Pole, and the other end towards the South Pole: for about theſe two ſtarres the whole heavens are moved, they remaining immoveable. The North Pole is a ſtarre in the North part of the heaven, being raiſed above the earth or our Horizon 52.^{d}. And this changeth his height, if you goe Northward or Southward one degree in 60. miles: but Eaſtward or Weſtward it altereth not. The elevation of the Pole is the height of this Star above the earth.

Obſerve alſo, that the Subſtile is the line or place over which the Stile or Gnomon in your Diall directly hangeth. The ſpace betweene Stile and Subſtile is the juſt height thereof.

One line cutteth another ſquirewiſe, when they make right and equall angles.

The Contingent or touch line, is that which is drawne by any point of another line or circle, ſo that it toucheth the ſame: and this line commonly in all Dialls is drawn ſquirewiſe to the ſubſtile,

A quadrant is the forth part of circle.

The Meridian and twelve a clock line are all one.

I call theſe lines parallell, which are every where of like diſtance one from another: example whereof you may ſee in the Eaſt and Weſt diall, where all the houre lines be parallell.

You may make all kinds of plaine Dialls upon one ſtone, if you prepare it firſt to be ſquare like a Dye, and then take off the eight corners, and all the ſharpe ſides, ſo ſhall you have 25. plaine plats beſides the baſe, or foote whereon your Diall muſt ſtand

If any be deſirous to have this inſtrument ready made, let him enquire at the Printers, and he ſhall heare of them.

THE

The making of an Inſtrument to finde out the ſituation of any plat or Diall, and to place them already prepared.

Chap. I.

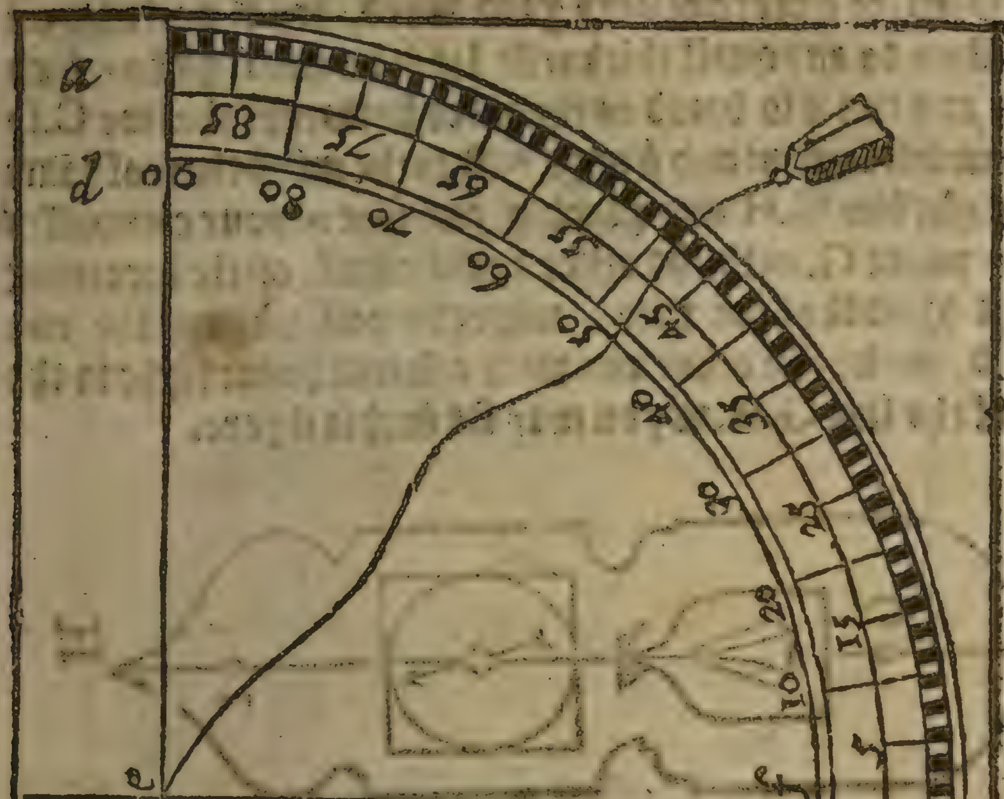
Foraſmuch as it is neceſſary before you can draw any Diall, to know how your plat is already or ought afterward to be placed, it ſhall be expedient to ſhew the making and uſe of an Inſtrumēt whereby you may examine and try all plaine plats and place all dialls being ready made and prepared.

Provide thereof an half circle of Peartree, Walnuttree, Box, or any other cloſe grained and ſolid wood beeing well ſeaſoned, ſo that the alteration of the weather at any time may not make it change from the firſt proportion thereof. Let it be perfectly tryed on both ſides of an even thickneſſe halfe or three quarters of an inch thick or more if you will, and ſix or eight inches broad as you thinke good. The edge or ſide A.B. muſt be very right. Then draw the Line C.D. three quarters of an inch equally diſtant from the ſide *A*.B place one foot of your compaſſes in the centre E. which is the midſt of the line C.D. and with the other draw halfe a circle from C. to A. divide it into two equall parts or quadrants and laying your ruler upon the centre E. and upon this Diviſion draw the line E.F. this done, divide each of theſe quadrants into 90 equall degrees of parts, which you may thus doe: Firſt, divide each of them into 3 equall parts and every of theſe into three other parts, ſo ſhall you have 9 diviſions in either quadrant, whereof every one ſhall repreſent ten degrees. Againe, part every one of theſe into 2. and each of thoſe into five (if you can) and ſo is each quadrant divided into 90 degrees.

Moreover, it were neceſſary if your inſtrument were large enough, to part each degree into 60 minutes or at the leaſt into 3. whereof each part may containe 20 minutes This done, faſten a thread well waxed, in the centre E. with a plummet of lead on the end, ſo that it may move at free liberty.

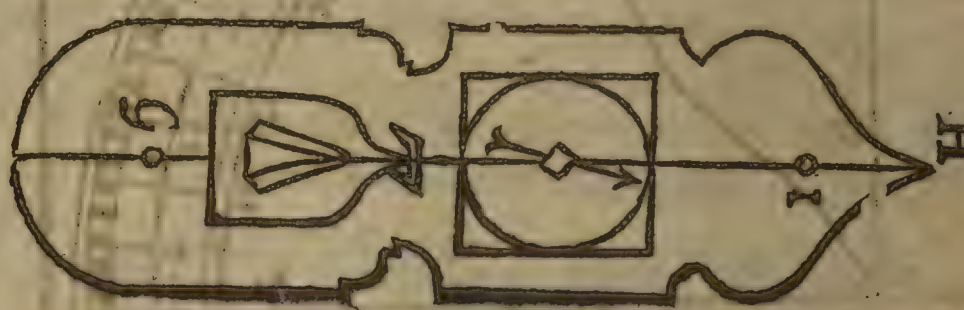
You may alſo (if you will) upon this ſide of the quadrant betweene E.D. draw the diall, whoſe delineation is caught in the 28 Crapter.

The


a
d
e
c
b
90
80
70
60
50
40
30
20
10
5
85
75
65
55
45
35
25
15
It were neceſſary to have here a little hole with a cover to put in your plummet & thread

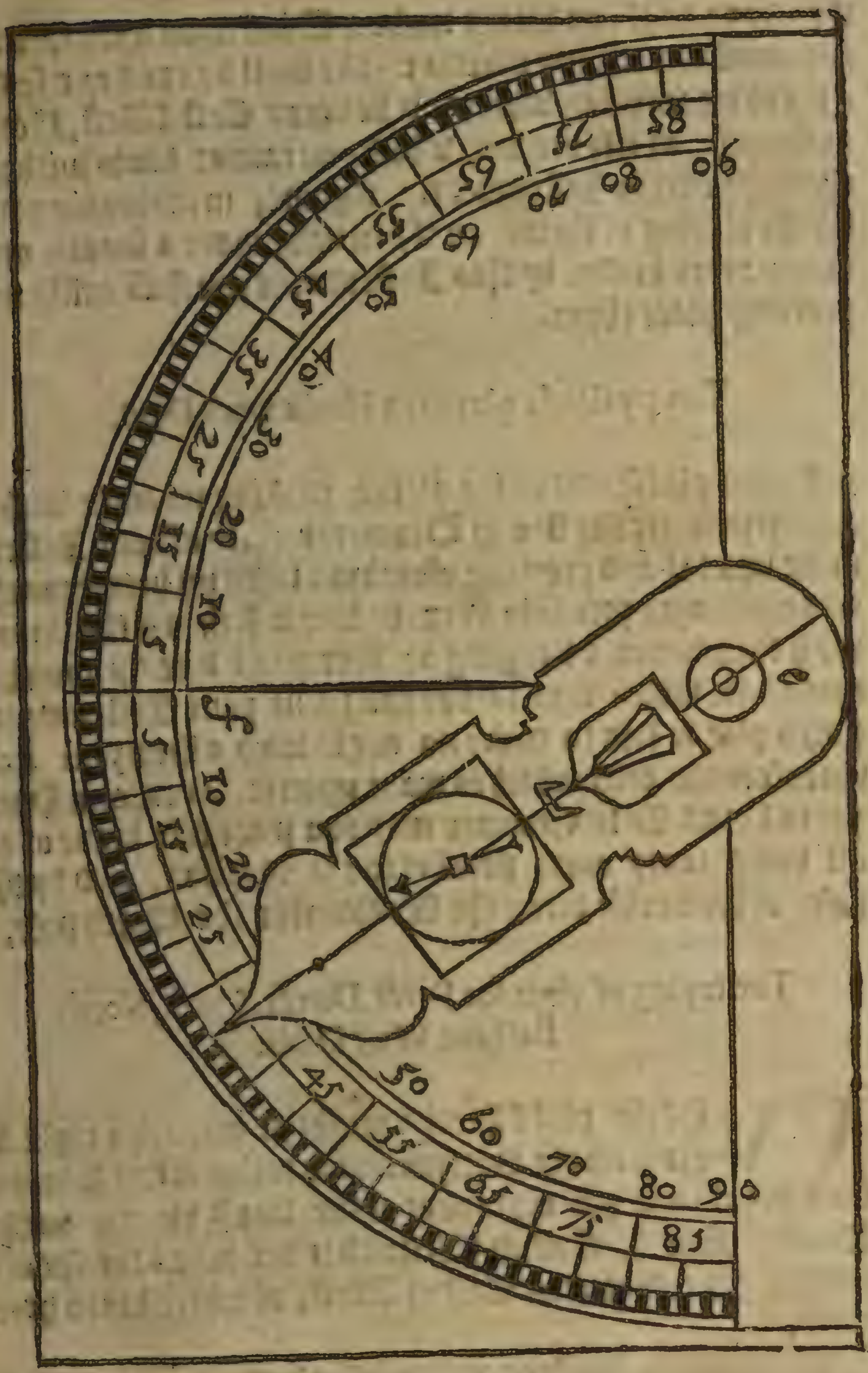
The former ſide of your Inſtrument thus finiſhed let the other be altogether like unto it, except that in ſtead of the thread with the plummet, you muſt haue a plumbrule made in this manner.

Prepare a piece of very good wood, try it perfectly on both ſides to an equall thickneſſe let it be about half an inch thick, and twice ſo broad as the ſpace betweene the line C.D of your inſtrument and yͤ edge A.B. in the midſt thereof draw the right line G.H and placing one foot of your compaſſes in the poynt G. with the other make a halfe circle according to the breadth of the ruler, whereby you may cut the end round, make the other end with a ſharpe point right in the end of the line G.H. as you may ſee in this figure.



¶ Let the diſtance betweene the point G. and the end H. be ſo much as is the ſemidiameter of the quadrant make by G ā hole ſo great, that a plummet of lead hāging by a thread from the ſharpe end, may move therein at liberty: Make alſo another round or ſquare hole, wherein you may place a needle touched with a Loadſtone, as in the compaſſes or dyals you ſee. Finally, make a little hole in the point or centre G. and with a broadheaded naile of braſſe faſten it upon the centre E. of your inſtrument, ſo as it may move and turne which way you will, and then your Inſtrument is finiſhed.

Note that you may make your Inſtrument in a forme of a quadrangle right angled, as Witekindus teacheth, cutting a round furrow without the circle and degrees made, for yͤ plummet to hang at liberty in: ſo ſhall you neede but one ſide of your inſtrument to uſe with a compaſſe or needle touched with the Loadſtone for the declinations. But the forme of the other, whoſe making we have taught, ſeemeth more cōmodious, behold the Figure.



The uſe of this inſtrument. CHAP. 2.

The uſe of this inſtrument is in examining and placing the plat or diall. In immoveable plats, to know how they ſtand, as if you would make a Diall upon a wall, firſt you muſt underſtand whether the wall be erect or elſe recline or incline: then whether it be direct Eaſt, Weſt, North or South, or elſe decline, which you cannot know without the helpe of this Inſtrument. Againe, in moveable plats for the placing of them, as if you have made a South diall or any other kinde, by this Inſtrument you ſhall eaſily and perfectly place them.

The tryall of a plat for a Horizontall Diall.

IF your plat ſeeme to lye plaine, making no angle with yͤ Horizon, let the ſide or Diameter A.B. of your Inſtrument upon it, and erect the plumbrule right up betweene the two quadrants preciſely over the line E.F. then if the thread with the plummet hanging at liberty fall directly upon his line G.H. which way ſoever you turne your Inſtrument, ſuch a plat is ſaid to make no angle with a Horizon: and therefore the diall which is made upon it, is called a Horizontall diall. In like manner may you place this kinde of diall being ready made perallel to the Horizon, and by the helpe of the needle direct the ſtile towards the North pole,

The trying of plats for Erect, Direct, South, North, East and Weſt Dials.

VVhē the plat ſtādeth upright, it maketh a right Ãgle with the Horizon and is called Erect, whereof ſome behold one principle part of the world directly as the South, North, Eaſt, or Weſt: other decline as the South and North, toward the Eaſt or Weſt, of which kinds hereafter.

To examine an Erect plat apply the ſide or diameter A.B. of your Inſtrument unto it, the thread with the plummet on the foreſide hanging at liberty. If the thread fall upon yͤ line E.C.F.D. the plat is Erect.

This done. apply the ſaid line or diameter A.B. to yͤ plat your Inſtrument being placed equally diſtant to the Horizon, and the plumbrule upon the line E.F. then if the needle ſtand directly over his caracter, the end touched with the Loadſtone being next to the plat, that plat is called a South Erect Direct.

In the north all the foreſaid things are to be conſidered except only that the end of the needle touched with the loadſtone is fartheſt from the plat.

These things knowne, you may eaſily find out the Eaſt and Weſt Erect Direct, if either you have a line drawn ſquirewiſe to the caracter of the needle, or elſe if you place the plumbrule over the line E.C. or E.D.

And here note, that the Eaſt and Weſt are not ſaid to decline, becauſe the Declination is accounted from the ſouth and North: to the direct Eaſt and Weſt points.

The examining of plats for Declining Dialls.

All ſuch plats as behold not ſome principall part of the world directly, are called Declining. The quantity of their Declination is found out thus.

Apply the diameter A.B. of your Inſtrument to the plat remembring to hold it out equally diſtant from the Horizõ. Then move the plumbrule untill the needle ſtandeth right over the caracter, and the point of the ruler which toucheth the degrees in the limb, ſhall ſhew how many degrees and minutes it doth decline: either toward the eaſt if the plumbrule lye in the quadrant C.E.F. or toward the weſt, if in the quadrant D.E.F.

The trying of ſuch Plats as recline.

IF the plat ſtandeth not upright, but maketh an obtruſe or ſlant angle with the Horizon, it is ſaid to recline. The degrees of the Reclination are found out thus.

Apply the Diameter *A.*B. of your inſtrument of the plat the one end placed upward, the other downward: then move the plumrule (the thread with yͤ plummet having free courſe untill the thread hang preciſely over the line G.H. then the poynt of the ruler ſhall ſhew the degrees of Reclination.

How inclining plats are tryed

BUt if the angle which the plat maketh with the horizō be acute or ſharp, then it doth incline. The quantity of inclination is thus known.

Apply the Diameter *A.*B. of your inſtrument to the plat, the thread with the plummet of the former ſide hanging at liberty, and marke what degree and minute the thread ſhall cut, for ſo much is the inclination.

The manner of trying thoſe plats which recline and decline, or incline and decline.

IF your plat ſhall both recline and decline or incline and decline: Firſt ſeeke out the reclination as hath been ſhewed, and then the declination as in Erect Declining.

The making of a horizontall, or plaine lying Sun Diall.

CHAP. 3

YOur plat being prepared ſmooth and plain, draw upon it two lines as in the figure following the one A. B. the other C.D. cutting themſelves ſquirewiſe that is making right angles in the point E. upon which make the quadrant of any circle from the line E.C. to the line E.A or E.B. and write at C. the North at D. the South at A. the Eaſt, at B. the Weſt. And the line C.A. which here is the quadrant being divided into 90. degrees or parts, the elevation of the Pole ſhall be accounted in it (which in our example is 52.^{d}. from C. to A. and at the end of this number draw a line from the centre E. which ſhall be E.F. repreſenting ẏ Stile and Axtree of the world. Then draw another line K. L. by C. or by ſome other point of the line C.D. ſquire-wiſe, ſo long as you can, which ſhall be called the touch line, or line of Contingence. Then meaſuring with your Compaſſes the leaſt diſtance of the point O. and the line E.F. for ẏ Stile, the one foot placed in O. which is the point of interſection, and the other extended toward E. where it ſhall chance to divide or be placed in the line F. C. marke that point or centre with the letter G. and draw with your Compeſſes a halfe circle upon this centre for the Equinoctiall circle, from H. by C. to I. whoſe Diameter muſt be equally diſtant to the line L. K. then divide this half circle into 12 equall parts: this done lay a Ruler upon the centre G. and upon every marke or diviſion made in the halfe Equator and where the Ruler ſhall touch the line of Contingence, there make markes or pricks, by which prickes draw lines from E for the houres E. C. is the 12 houre E. B. the 6 in the morning E. A. the 6 at evening, the reſt you may ſee in the Figure.

And whereas in Summer the 4 and 5 in the morning, and alſo the 7 and 8 at evening, ſhall be neceſſary in this kinde of Diall: prolong or draw the lines of 4 and 5 at evening, beyond the centre E. which ſhall ſhew the houres of 4 and 5 in the morning. And likewiſe the 7 and 8 in the morning, for the 7 and 8 at evening.

You may obſerve an order both in theſe and in all other erect direct Dialls, by dividing the one halfe of the Equator drawing houre lines for the forenoone, and obſerving the ſame diſtance from the Meridian line, on the other ſide for the afternoone: for the line of the 11 houre in the forenoone, is of like diſtance from the Meridian, that the 1 is in the afternoone, and the 10 as 2 and ſo of the reſt.

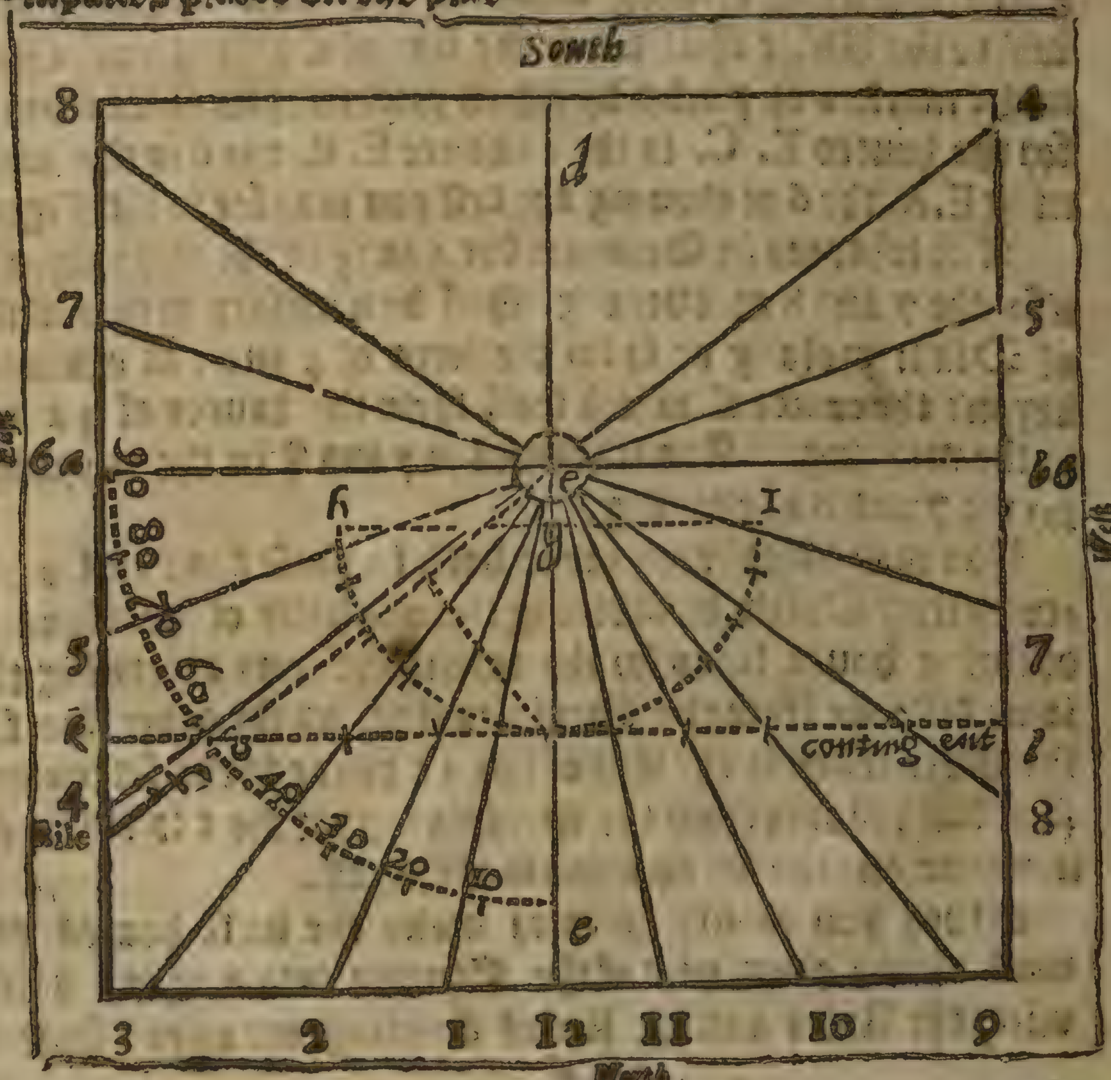
When you would draw or make the halfe houres, you muſt divide every part of the Equator into 2 equall parts, uſing the Ruler and the line of Contingence as you finde in the drawing of the houre-lines.

And this remember for the drawing of the halfe houre-lines, not onely in this kinde, but alſo in all other kindes of dialls which afterward ſhall follow.

The Stile muſt be fixed in the centre E. hanging directly over the Meridian line E.C. with ſo great an angle, as the lines C.E.F. make, declining from that on neither ſides.

The equinoctiall circle, the Quadrant, the line of the Stile and of Contingence muſt be lightly drawne, becauſe they ought to be put out againe, in that they ſerve to no uſe but for drawing of the Diall. And this likewiſe remember in all other kindes of Dialls, that the preparative or pricked lines muſt after the making of the Diall, be omitted and extinguiſhed, as altogether unprofitable.

This and all other kindes of Dialls may moſt fitly be drawne upon a cleane paper, and then with the helpe of your compaſſes placed on the plat

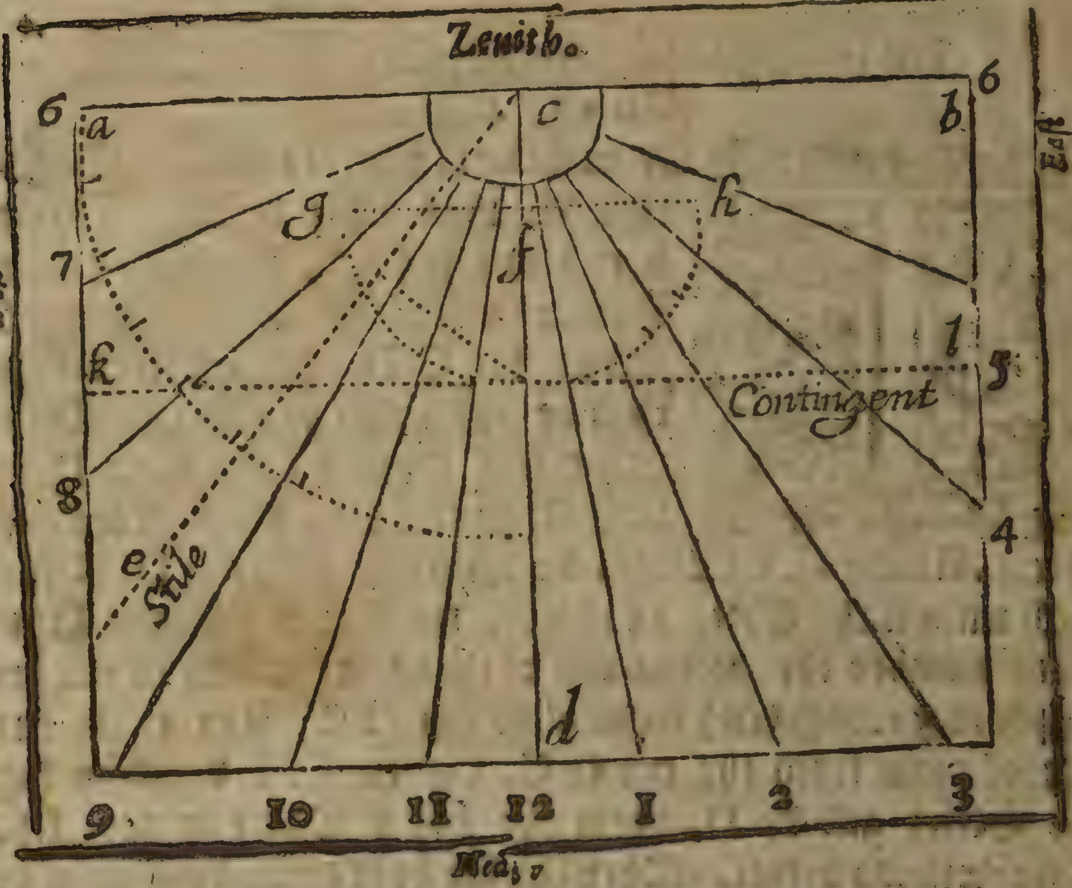


The

The making of a ſouth erect, direct Diall.

CHAP. 4.

The making of this, is almoſt altogether like unto other before. Draw here alſo a line A.B. Paralel to the Horizon, out of the middeſt whereof, let the line C.D. perpendicular to that be extended: and let the Quadrant bee drawne from A. to D. or B. to D. parted into 90 degrees, as before. Above C. let Zenith be written, beneath D. Nadir; nigh unto B. the Eaſt, and by *A.* the Weſt. In the Quadrant number the Elevation of the Pole (which in our example is 52. degrees) from *A.* toward D. And at the end hereof draw from the centre C. the line C. E. repreſenting the Stile: and by D. draw the line of Contingence, I.K. ſquirewiſe, as before. Then the leaſt diſtance of the point or interſection D. and the Stile being taken with your Compaſſes extend them in the line D.C. the one foote placed in D. ſet the other in F. toward C. and draw by F. the Diameter of the halfe circle of the Equator equall diſtant to the line K.L. which muſt be made upon the centre F. from G. by D. to H, and divide it into 12 equall parts, upon every one of which and yͤ centre F. the ruler being placed, whereſoever it ſhall happen to touch the line of contingence, there make markes. Then from the centre C. by theſe markes the houre-line muſt be drawne. The line C.A. ſhall ſhew the 6 houre in the morning C.C. the 6 at evening, C.D. the 12 &c. The Stile muſt be placed or fixed in the centre C. hanging preciſely over the line of the 12 houre, with ſo great a diſtance as the angle D.C.E. is. This kinde of Diall doth receive and ſhew but 12. houres at the moſt.



The Making of a North Erect direct Diall.

Chap. 5.

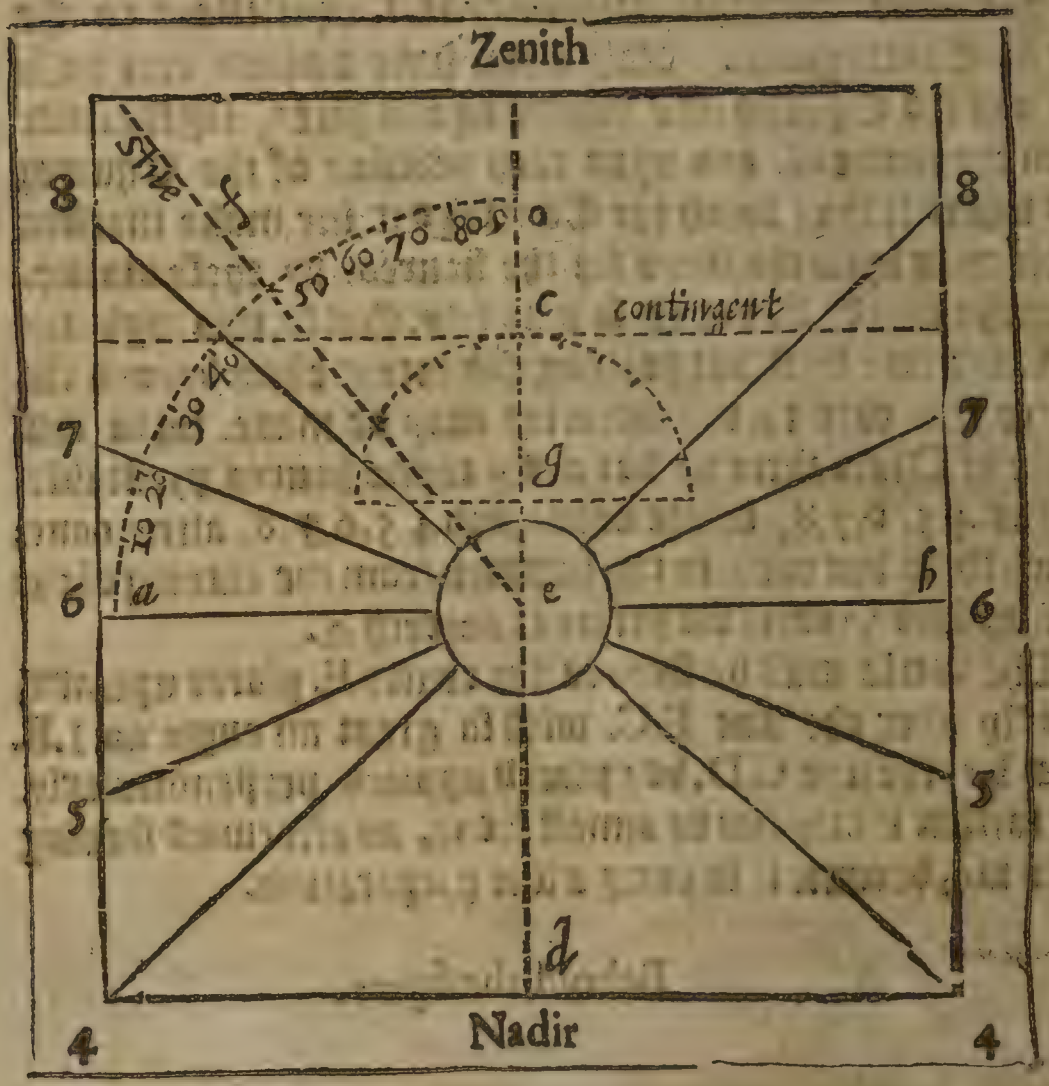
Here as in the South make a line Parallel to the Horizon, A. B. put it ſquare-wiſe with the Perpendicular C. D. let C. bee the centre. At C. write Zenith, at D. Nedir, &c. From C. draw the Quadrant of a circle to D. or B. divide this into 90 Degrees, account the Elevation of the Pole (which in our example is 52.^{d}.) from A. toward C. Draw at the end of this number the line E. F. for the Stile. Afterward draw the line Contingence by C. ſquire-wiſe and take the ſhorteſt diſtance with your Compaſſes betweene the point C. and the Stile, placing the one foot in the point

C. extend the other toward E. in the line C. D.: making a Point or prick G.: whereupon (as a centre) the ſame wideneſſe of the compaſſes remaining, deſcribe the half Equator by C. ended with the Diameter. H. I. equidiſtant to the line of Contingence. When you have divided this halfe circle of the Equator into twelve equall parts, lay the ruler upon the centre G. and upon each diviſion of the Equator and where it ſhall touch the Contingent line, make markee This done draw the lines for the houres, by thoſe marke. from the centre E. but thoſe very few. that is, two nigh unto A. and two by B. but prolong and extend them beyond the centre E. ſo that their contraries may be made. for in this kinde of Dials there be but onely tenne houres profitable, that is, 4, 5, 6, 7, 8, before noone, and 4, 5, 6, 7, 8, afternoone; which ſhew but onely in the ſummer; from the entring of the Sunne into ♈ untill ſuch time it entreth ♎.

The Stile muſt be fixed in the centre E. placed upward, directly over the line E.C. with ſo great an angle as I.E.C. is. Let the line C.D. bee placed upward perpendicularly, but ſo, that it may not be almoſt ſeene, as afterward ſerving to no uſe, becauſe it is onely a line preparative.

Behold the figure.

A North Diall erect, direct.



The making of the Eaſt and Weſt Erect Dialls.

CHAP. 6.

If you know the making of one of theſe, you may eaſily make them both, for they be very like, differing onely in the naming of the houres, for the one containeth houres for the forenoone, and the other for the afternoone.

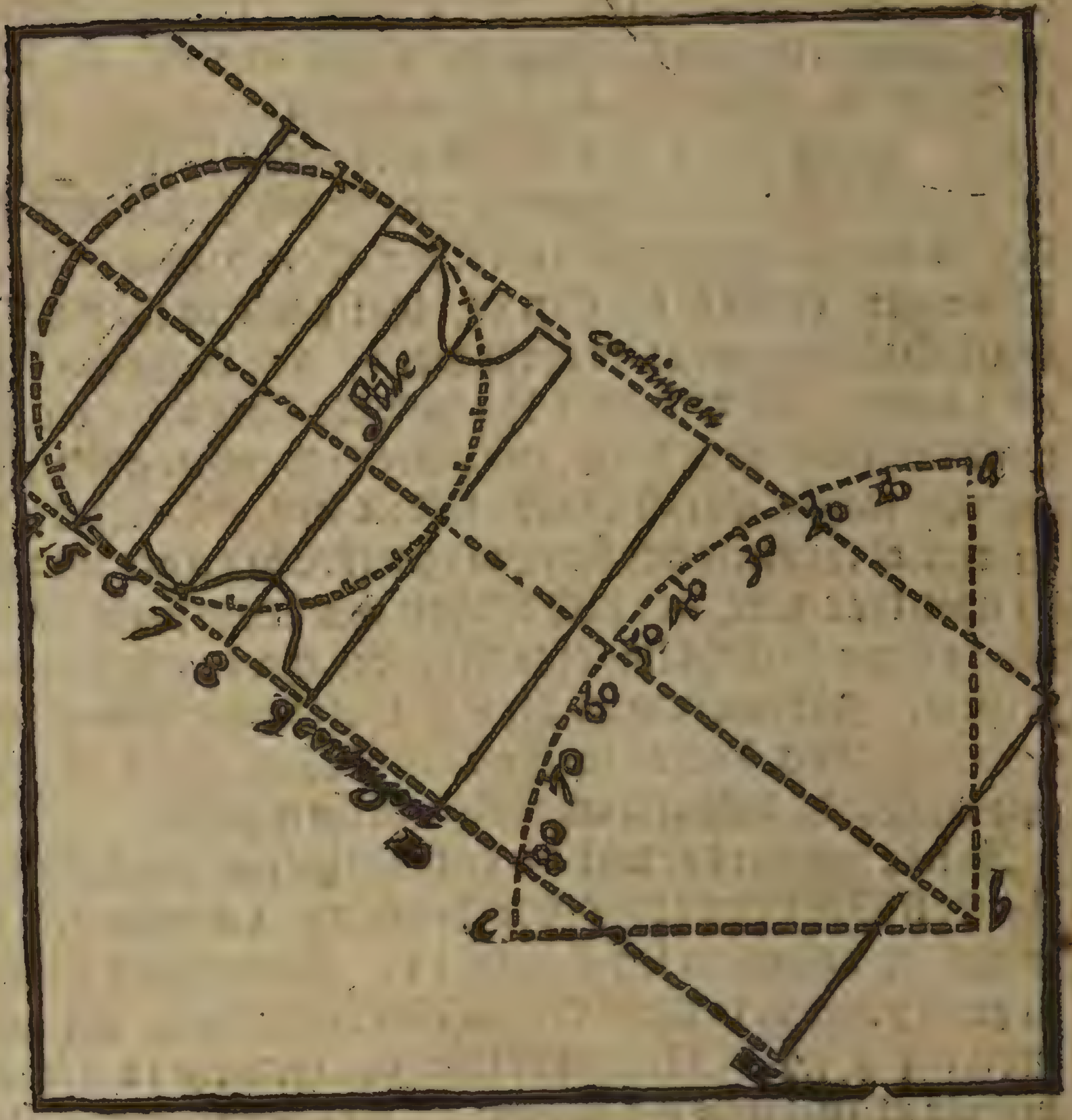
You muſt therefore on your plat make the Quadrant of a circle A.B.C. which may afterward be eaſily put out, as all the other lines muſt bee; except the houre lines: let the A.B. be Perpendicular B.C. Parallel to the Horizon and let the arke behold the South, which being divided into 90.degrees, number therein the elevation of the pole downward from A. toward C. by the end of this number, and by the centre B, draw a line ſo long as your plat will give you leave, whoſe South end ſhall behold preciſely the Equinoctiall circle. At which end draw a circle, whoſe Diameter ſhall be almoſt the third part of the line. Then draw another, Diameter, or line in the Centre, ſquire-wiſe to the other, which ſhall ſhew the axtre of the world, and be the line for the 6.houre. Afterward at the outward ſides of the circle draw two contingent lines, one beneath, the other above, ſo that they may be Parallel to the middle line. Divide each quarter of the circle into ſix equall parts. Then place the ruler upon the centre, and each of thoſe markes or parts, and where it toucheth the line of contingence, there make marks in them. Afterward draw a line by thoſe two marks which be next to the 6. houre, in the lines of contingence, which may be equally diſtant from the line of the 6.houre.

In like manner doe with the reſt; ſo that you may have in the Eaſt Diall, two above the 6.houre, the 4.and the 5.in yͤ morning, and under it 7,8,9,10,11. In the Weſt Diall likewiſe 7.and 8. in the evening above the 6.houre, and under it 6,5,4,3,2,1. Neither of them doe ſhew the 12 houre, becauſe at that time the Sunne beames be parallel to the plat.

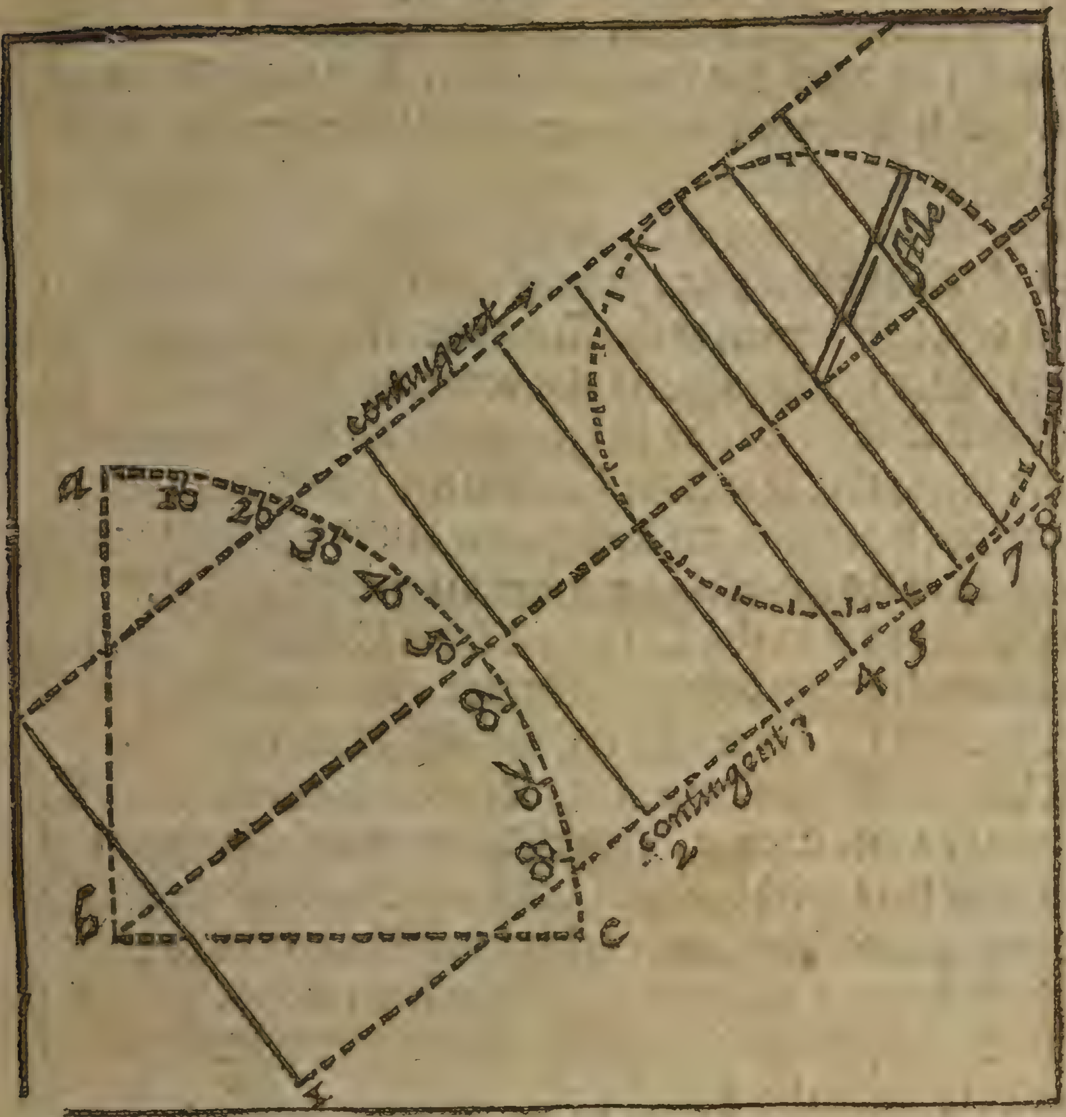
Fix the Stile in the centre of the circle right up from the Plat, ſo long as the Semidiameter of the circle is onely ſhewing the houre with the very top or end thereof. Yet it were more convenient to have it placed along over the line of the 6.houre, being a plate of yron or ſome other metall, being ſo broad as the Semidiameter of the circle is.

Behold the figures following.

An Eaſt Diall Erect.



The weſt Diall erect.



Note that theſe five kindes of Dial's before taught may be made upon a ſtone cut ſquare in the forme of a die.

The making of a South Erect declining Diall, which may be placed on any upright wall whatſoever.

Chap. 7.

IN all Declining Dialls becauſe the Stile doth not hang directly over the Meridian line, therefore you muſt firſt finde out and place the Subſtile (which is the line over which the Stile directly hangeth) and likewiſe the line of the Stile: which may be both eaſily and ſpeedily performed in this manner.

Firſt by your Inſtrument ſeeke out the Declination of the wall or plat, whereupon you would make a Diall, which for example ſuppoſe I had found to be 50 degrees.

Therefore draw the Horizontall A. B. let the Meridian C.D. cut it ſquirewiſe in the point E. which may be in any place of the line A.B. and let the line F.C. cut the Meridian ſquire-wiſe in the point C. which you may likewiſe take in what part of the Meridian you thinke moſt convenient. Upon the centre E. deſcribe the Quadrant of a circle from C. to A. if the Declination of your plat be weſtward, or from C. toward B. if Eaſt-ward (as in this example it is) divide it into 90.^d. and number in it from C. toward B. the Elevation of yͤ *Equator 38. degrees and laying your Ruler upon the centre E. and upon the end of this number, draw the line E.H.

Again, account in the Quadrant from C. toward B. the declination of the plat being 50. degrees, and draw the line of Declination E.I. from E. to the end of this number.

Then take your Compaſſes, ſet one foote in the point C. extend the other unto H. (which is the interſection point of the line of E.H. with the line C.G.) and that ſame wideneſſe remaining, place one foote in the centre E. and with the other marke the point I. in the line E.I. and from the point I. draw the line I.K. ſquirewiſe to the Meridian E.C. placing K. at yͤ interſection it maketh with E.C.

Moreover take with your Compaſſes the Iuſt length of the line I.K. and placing one foot in C. turne the other toward F. and make the point L. in the line C.F. draw the Subſtile from E by L. Let the line of Contingence be drawne ſquire-wiſe to the Subſtile in the point L.

This done, take the diſtance betweene the centre E. and the point K. and place it in this line of Contingence from the point L. unto M. and make the point M. that the line E.M. may be made from E. unto M. for the Stile.

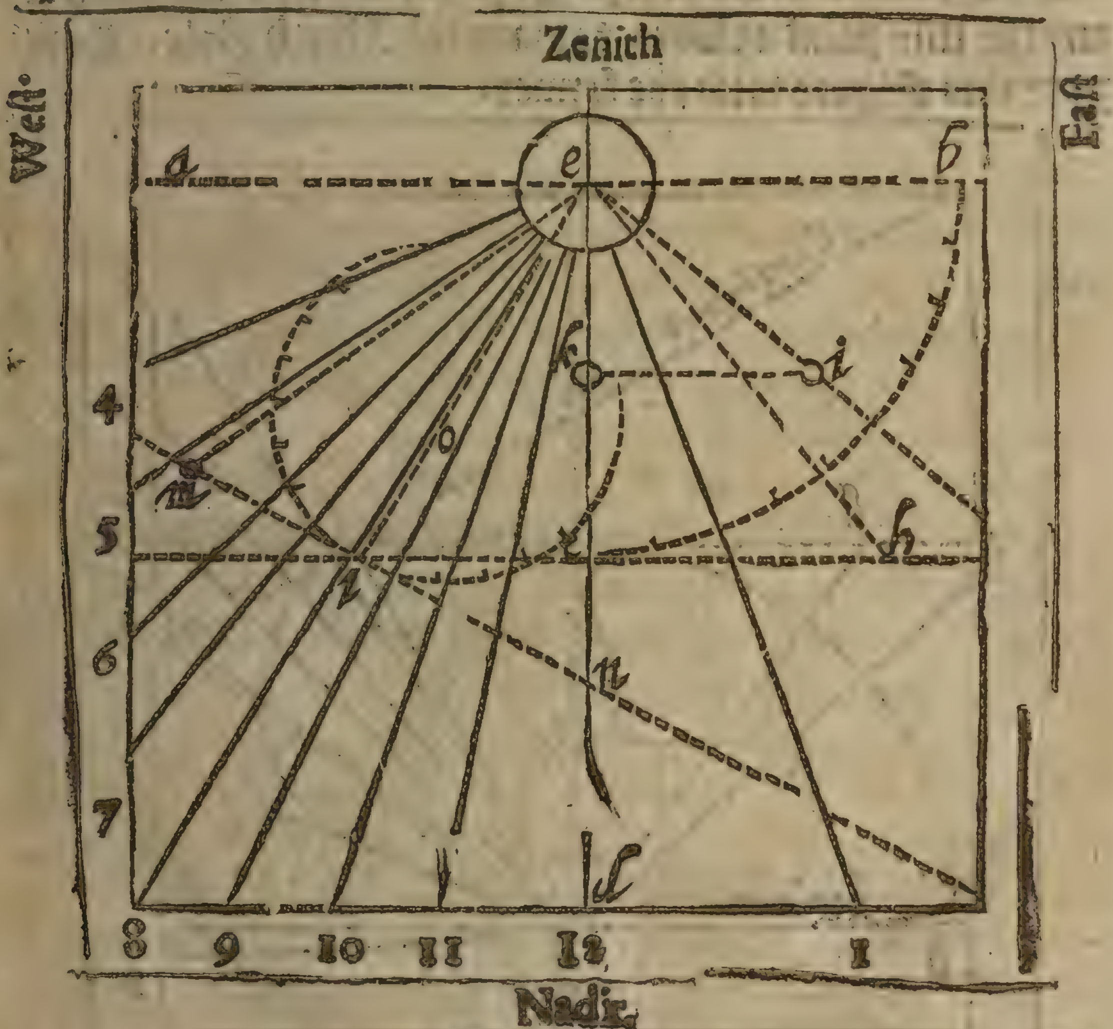
Meaſure with your Compaſſes the leaſt diſtance betweene the point L. and the Stile, and with the ſame wideneſſe, one foote remaining in L. turne the other toward E. and make the centre O. in the Subſtile upon which deſcribe the Equi-

noctial

noctiall circle. Then placing your Ruler upon O. being the centre of the equinoctiall circle, and N. (which is the point of the interſection of the Meridian & Contingent) marking where it cutteth the circumference: for there you muſt begin to divide it into 24. equall parts, notwithſtanding thoſe 12 are onely in uſe which are next the Contingent.

Finally, place your ruler upon the centre O. and upon the ſeverall diviſion points of the Equator, and where it toucheth the line of Contingence, make markes, by which from the centre E. draw the houre lines.

Place the Meridian perpendicularly upon the wall, the centre E. upward, the Stile pointing downeward. Let the Stile hanging directly over the Subſtile making an angle equall to E.M.I.

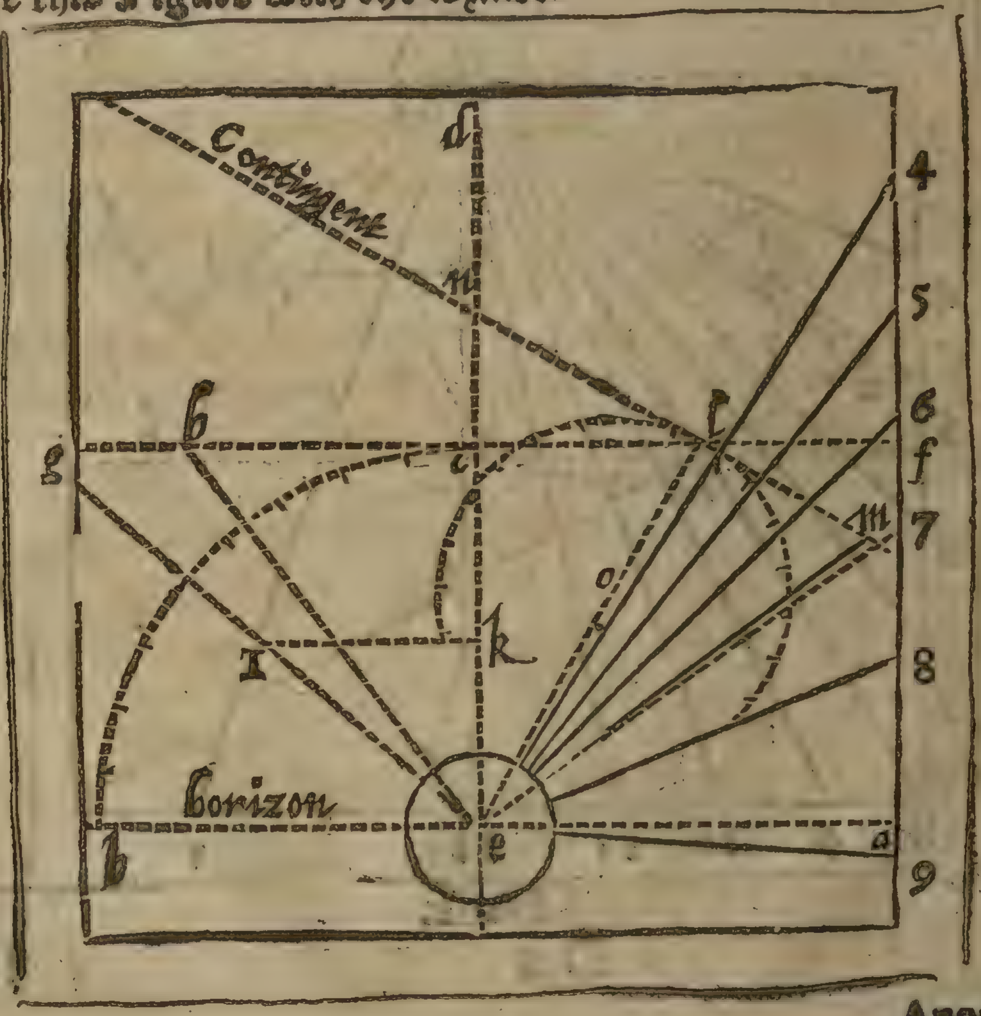


The making of a North Erect Declining Diall. Chap. 8.

The North Erect declining Diall differeth from the South onely herein, that the centre is to be placed downeward, the ſtile pointing upward to the North Pole. and that the Meridian repreſenteth the 12 houre at midnight and at noone. Therefore if the declination be toward the Eaſt, you muſt account the houre lines from that which is as it were the Meridian forthward, 1 2 3 4 5, 6, &c.

But if it decline toward the Weſt number them backward, 11, 10.6, 8 &c. omitting the firſt 3 which are before Sunne riſing and after Sunne ſetting in our Elevation.

Let the line E.D. be placed perpendicularly upon the plat and the ſtile point upward toward the North Pole. Compare this Figure with the former.



Another way to make a South Erect Declining Diall.

Chap. 9.

Albeit we have plainely and perfectly ſhewed the making of the South and North Erect Declining Dialls, in the two former Chapters; yet to ſatisfie them that delight in varietie; here is a ſo declared another way, whereby you may make them namly by the helpe of Arithmeticke, and the Table of Signes which is placed in the end of this booke for this intent.

Therefore the Elevation of the Pole being knowne, and the Declination of your plat, by your Inſtrument found out:

Multiply the Signe of the Complement of the Elevatiō by the Sine of the Complement of the Declination, divide the product by the whole Signe (which is a 100000) and you ſhall have a quotient Signe, whoſe Arke is the diſtance of the Stile from the Subſtile, which diſtance keepe.

Then take the Complement of this diſtance, and the Elevation of the Pole, and multiply the Signe of the leſſer by the whole Signe, parting the product by the Signe of the greater: the quotient Signe which ſhall come of this diviſion, ſhall give you an Arke whoſe Complement is the diſtance of the line of the Subſtile from the Meridian, which diſtance you ſhall likewiſe keepe. For better inſtruction herein, conſider the Example.

Example of a South Diall Declining 45.^{d}. Elevation of the Pole 52.^{d}.

First I enter the Table of Signes, for the Signe of the Complement of the Elevation which is 38.^{d} and I find it to be 61566. Then I looke for the Sign of the Complement of the Declination, which is 45.^{d}.& I find that to be 70710. This done, I multiply the one by the other and the product is 4353331860. which I divide by the whole Sine being 100000. whereof commeth a quotient 43533. With this quotient Sine I enter the Table, and becauſe I finde not the juſt number, I take that which is next either greater or leſſe unto it: (which you muſt alwayes remember to doe) for ſo ſmall a difference maketh no alteration, & therefore I take in ſtead hereof 43523. whoſe Arke is 25.^{d}.48.^{m}. which is the diſtance of the Stile from the Subſtile.

Then I take the Complement of this diſtance, which is 64.^{d}.12.^{m}. whoſe Sine is 90031. and the Elevation of the Pole 52.^{d}. whoſe Sine is 78801. & multiplying the Sine of the leſſer, (which is the Elevation of the Pole) by the whole, 100000. the product is 7880100000. which I divide by the Sine of the greater, to wit, the Sine of the Complement of the diſtance of the ſtile from the Subſtile, whoſe Sine is 90031, whereof commeth this Quotient 87526 whoſe Arke is 61.^{d}.5.^{m}. The Complement of which Arke is 28.^{d}.55.^{m}. being the diſtance of the Subſtile from the Meridiã. These diſtances being thus found out, the drawing of the Diall followeth.

Firſt, draw a line Parallel to the Horizon A. B. out of whoſe middle point C. draw the Meridian line ſquire-wiſe C.D. upon the centre C. make the Quadrant of a circle betwéene A. & D. Here underſtand that generally in all kindes of Declining Dialls, if the declination be towards the Eaſt, you muſt draw the Quadrant towards the weſt, (except in yͤ South reclining declining, and the North inclining declining where the Contrary is preſcribed.) But if the declination be Weſtward the Quadrant be drawn Eaſtward: Hereby you ſhall eaſily know on which ſide you ought alwayes to draw the Quadrant, and which way the figures following doe decline. Your Quadrant being made, divide it into 90. degrées: number therein from D.

the diſtance of the Subſtile from the Meridian, which is $25.^{d}.55.^{m}$. Draw at the end of this number the line C.E. for the Subſtile, Then from E. towards A. account the diſtance of the Stile from the Subſtile, which is $25.^{d}.48.^{m}$. and at the end hereof, draw the line C.F. for the Stile. Afterward by the point E. or in any place of the Subſtile draw the Contingent G.H. ſo long as you can ſquire-wiſe to the Subſtile. Then take with your Compaſſes the leaſt diſtance betweene *E.* and the Stile the one foot remaining in E. and then the extended in the Subſtile toward C. place at the pricke there made with the Compaſſes, I. upon which pricke as a centre, the ſame wideneſſe of your Compaſſes remaining, draw a circle by E. which ſhall repreſent the Equinoctiall or Equator. Then lay the Ruler upon the point I. and the interſection (whoſe marke is K.) of the line of Contingence, and the line C.D. (whith is alwayes drawne ſo that it may cut the other) and where the Ruler ſo placed ſhall touch the circle, there make a marke, and there begin to divide it into 24 equall parts: notwithſtanding thoſe 12 onely are to be uſed, which doe behold the Contingent line. Then lay the ruler upon the centre I. and the Contingent line by every diviſion of the Equator, and where it ſhall touch the line of Contingence, there make markes, by the which from the centre C. draw lines for the houres, ſo many as ſhall be neceſſary.

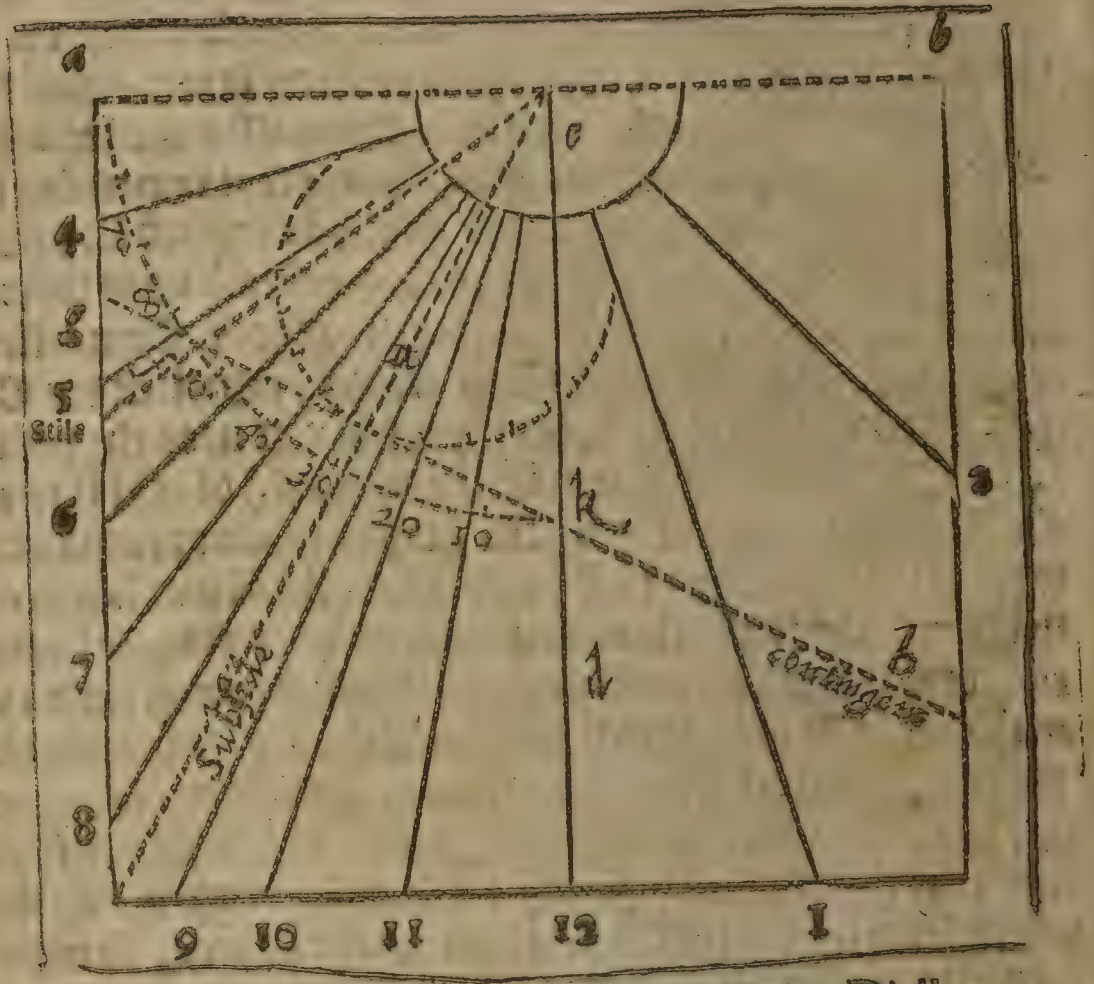
The line C.D. ſhall alwayes ſhew the 12. houre, which muſt hang perpendicularly. Number the reſidue of the lines in their place as they follow in order,

The line *A*.B. in ſuch as do decline is unprofitable, except it ſo chance that ſome houre line falleth in it.

Let the line be fixed in C. hanging directly over the Subſtile, with ſo great an angle, as E.C.F. is, declining on neither ſide.

Note diligently the making of this declining Diall, becauſe in thoſe which follow, we meane not to repeate thoſe things which have here beene taught. And this one kinde well knowne all the other will ſeeme moſt eaſie. For better underſtanding hereof, behold the Figure.

A South Erect declining Diall.



The making of a north Erect declining Diall another way

CHAP. 10.

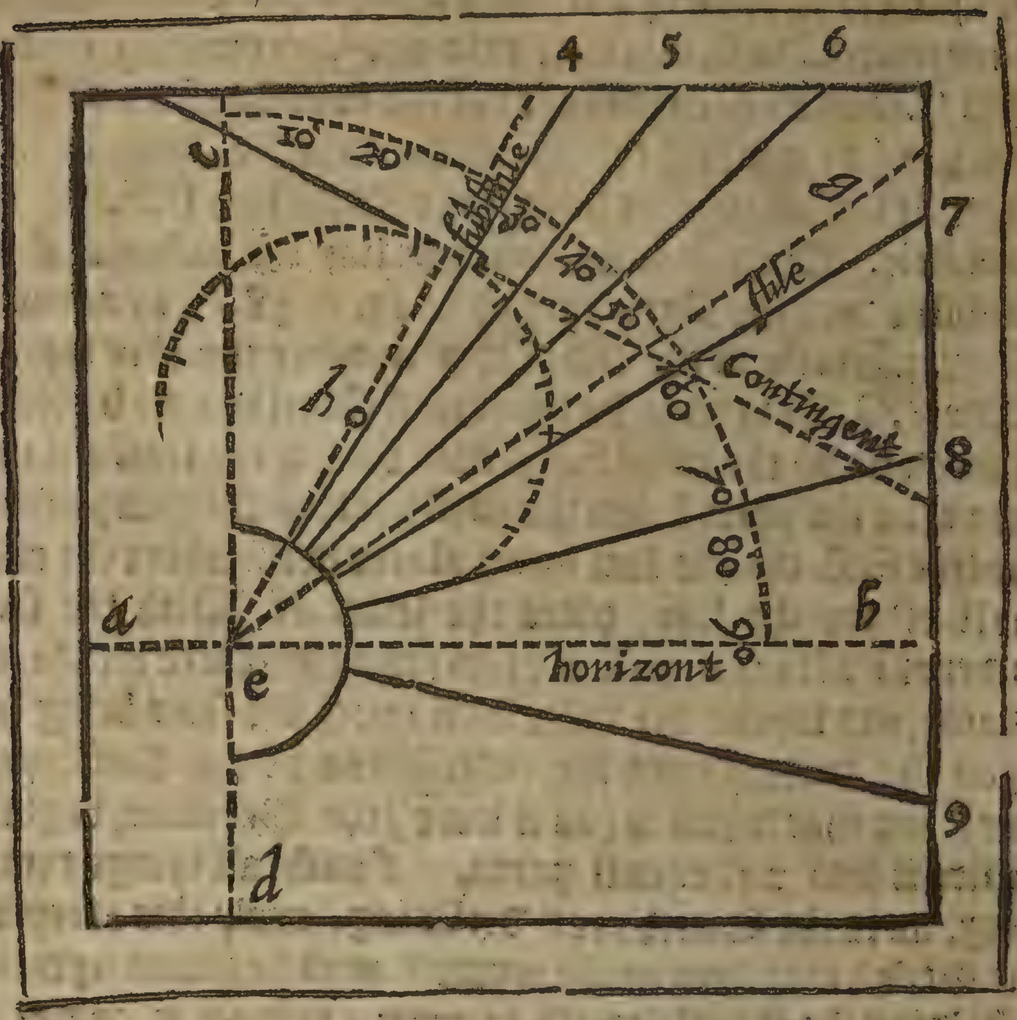
The diſtance of the Stile from the Subſtile, and of the Subſtile from the Meridian, is found out altogether like to the South Erect declining. Therefore you may reſort thither for the working hereof. I will onely draw the Figure.

Let the line A. B. being parallell to the Horizon, cut C. D. ſquirewiſe placing E. at the interſection. Draw the quadrant from C. to B. divide it into 90.^{d}. accounting therein from C. toward B. the diſtance of the Subſtile from the line, which is (as it were) the Meridian, which diſtance is 28.^{d}. 55.^{m}. At the end of this number draw the line E. F. for the Subſtile. Then number from that line the diſtance of the Subſtile and the Stile, which is 25.^{d}, 48.^{m}. towards B. Draw likewiſe at the end of this number the line for the Stile E. G. This done let the line of Contingence be drawn ſquarewiſe by the point F. and then taking the leaſt diſtance betweene the point F. and the Stile, extend the compaſſes in the line F. E. the one foot being placed in F. where the other ſhall divide the line, place the letter H. With the ſame wideneſſe of the compaſſes draw upon the centre H. the Equator, and where the ruler ſhall touch the ſame being laid upon the centre H. and the interſection of the Contingent line, and that which is (as it were) the Meridian, begin to divide it into 24. equall parts. Finiſh all things remaining, as in the South erect declining, onely this excepted, the Stile being fixed in the centre E. muſt be placed upward, beholding the Subſtile with ſo great a diſtance or angle, as the letters F.E.G. doe ſhew. The line C.D. being applyed to the plat perpendicularly, ſheweth as it were the 12 houre at midnight: therefore account from that the houre lines, as they follow in order, 1,2,3. which houres have no uſe in this kinde of Diall, for our Elevation, but from 4 &c.

Let the line A.B. be parallel to the Horizon, being lightly drawn, as the other preparative lines be, ſerving afterward to no uſe.

Note if the plat decline toward the Eaſt, as this figure doth it is for the forenoone; and you muſt account the houre lines from that which is (as it were) the Meridian forward 4,5 6 &c. If it decline toward the Weſt, account them backward 11,10,9 as we ſhewed before.

A north erect declining Diall.



The making of a Meridionall or South Reclining direct Diall.

CHAP. II.

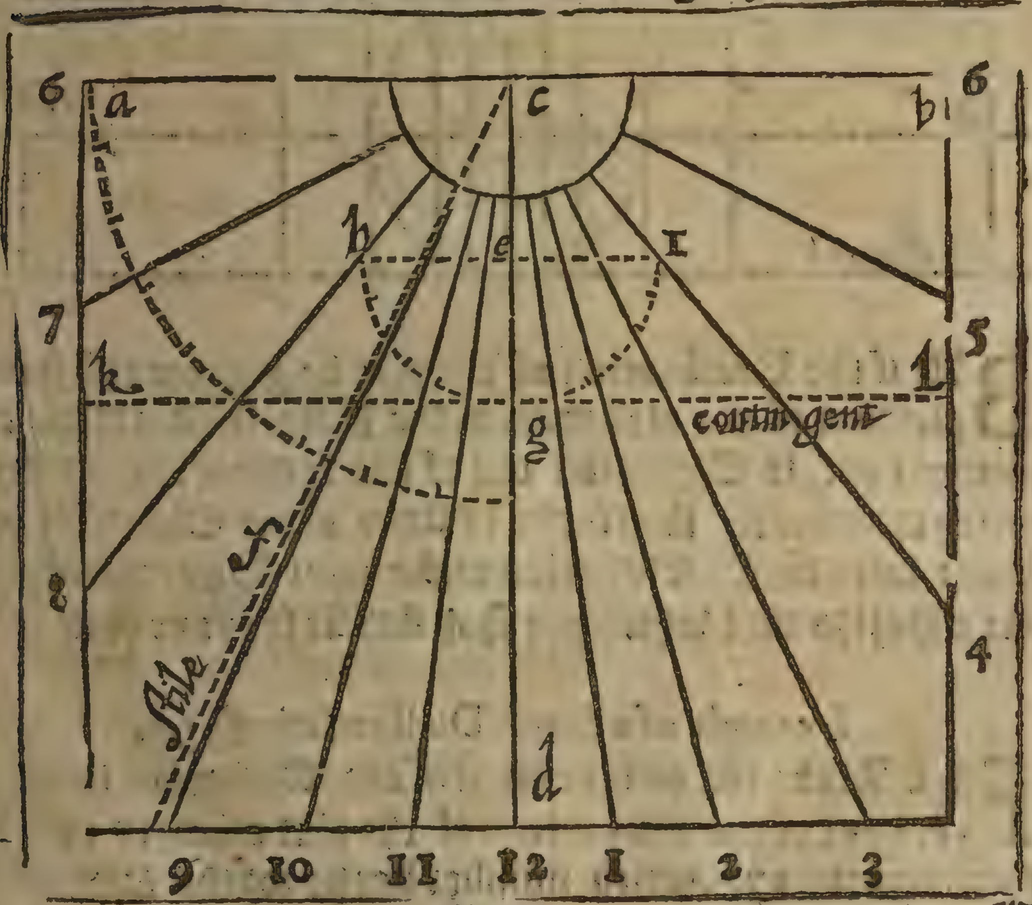
IF the Reclination of the plat bee leſſe then the complement of the Elevation of the Pole, adde this complement and the Reclination of the plat together, and with this number, as if it were the Elevation of the Pole, make a South erect direct diall and it will be perfect and fit for your plat.

Example

Example and delineation of a South Diall, reclining 25.^{d}.

Make the firſt line A. B. draw alſo another C.D. cutting the other with right angles. Then adde the Complement of the elevation of the Pole (which is 25.^{d}. to the reclination of the plat (which is 38.^{d}.) and the totall ſumme ſhall be 63.^{d}. which number being in place of the Elevation of the Pole, account it in the Quadrant from A towardes D. and at the end hereof, draw the line F. for the Stile. Then make the line of Contingence K.L. ſquarewiſe to the line C. D. Afterward take the leaſt diſtance with your compaſſes betweene the point G. and the Stile, with the wideneſſ, the one foote extended toward C. make a point or prick E. by which point draw the line H.I. equidiſtant from A.B. or K.L. upon E. make a halfe circle frõ H by G. to I. which being divided into 12. parts, finiſh the reſt as the ſouth erect direct.

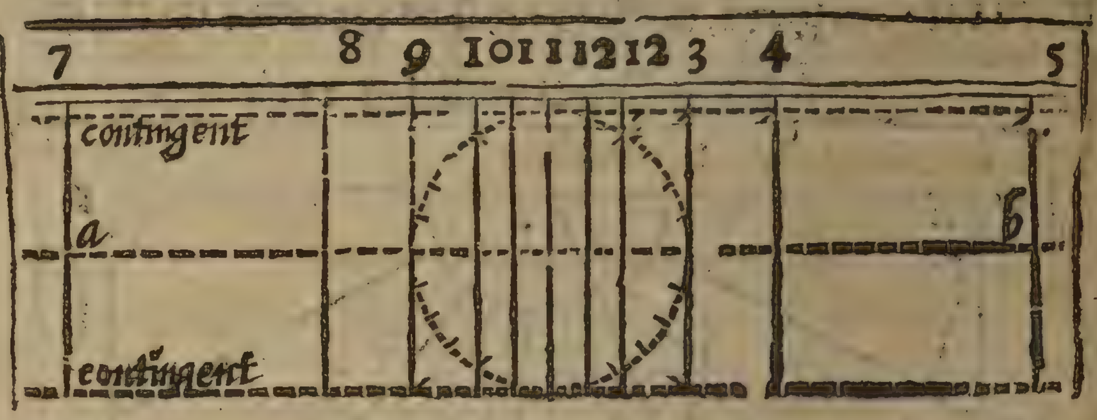
A South Direct reclining 25.^{d}.



BUt if the Reclination be equall to the complement of the Pole, make your Diall on this manner, like to the Eaſt and Weſt.

Draw a line Parallel to the Horizon A.B. ſo long as the plat will give you leave, divide it into 7. equall parts, and with the ſame wideneſſe of the compaſſes in the midſt of yͤ line make a circle repreſenting the Equator. Then draw two lines of Contingence by the circumference of the circle equidiſtant from the firſt A.B. Divide the Equator into 24 equall parts. Finiſh the reſt like the Eaſt or Weſt diall except in naming the houres, for that which is in them the 6. houre line, is here the 12. &c.

A South Direct reclining 38.^{d}.



BUt if the Reclination of the plat be greater thẽ yͤ complement of the elevation of the Pole, ſubſtract the cõplement of this Elevation out of the reclination, and that which remaineth ſhall ſerve in ſtead of the Elevation of yͤ Pole: with which Elevation make your Diall altogether like a Horizontall, which you ſhall find fit for your plat.

Example of a South Diall, reclining 55.^{d}.

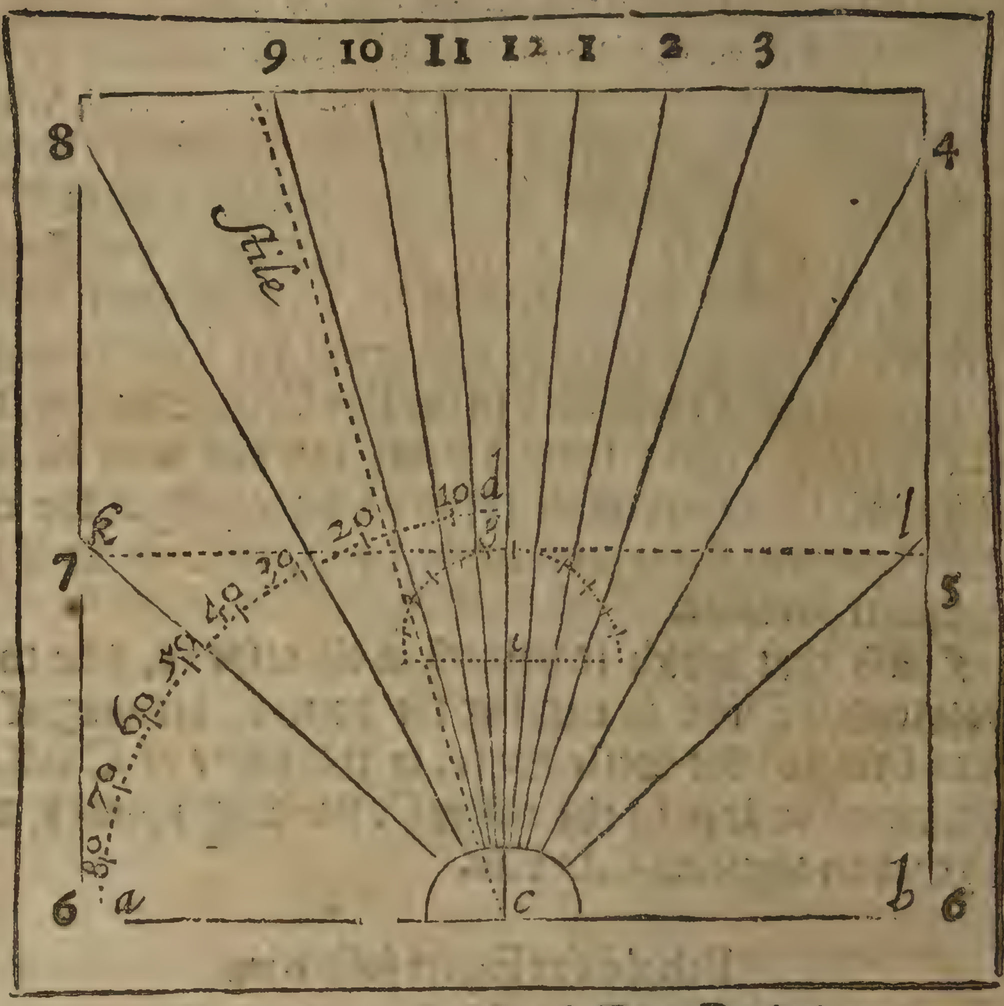
FIrſt I take the complement of the Elevation, which is 38.^{d}. out of the reclination of the plat which is 55^{d}. and there remain 17.^{d}. which number keepe for the Elevation of the Pole.

In Delineation of this Diall, draw a line Parallel to the Horizon A.B. draw another C.D.making right angles with the line A. B. Then make the quadrant from A.to D. which being divided into 90. degrees, number in it, that, which is,as it were the Elevation of the Pole, namely 17. degrees from D. towards A.Then draw the line of Contingence K,L. in any point of the line C. D. ſquarewiſe. Take with your compaſſes the leaſt diſtance of the point G. and of the Stile: extend them both in the line C.D. I meane,from G. toward C. make there a point marked with E. upon which point or centre with the ſame wideneſſe of the compaſſes draw the Equator from H. by G. to I. divide it into 12.equall parts,&c.

Finiſh that which remaineth in all reſpects, like to the Horizontall Diall, in naming the houres, drawing of the lines,fixing of the Stile,&c. for in this kinde of Diall, the Stile muſt be fixed in the centre C. ſtanding upward, with ſo great an angle,as C.D.F.is.

Behold the Figure following.

A South Reclining Erect



The making of a North Diall Reclining Direct.

CHAP. 12.

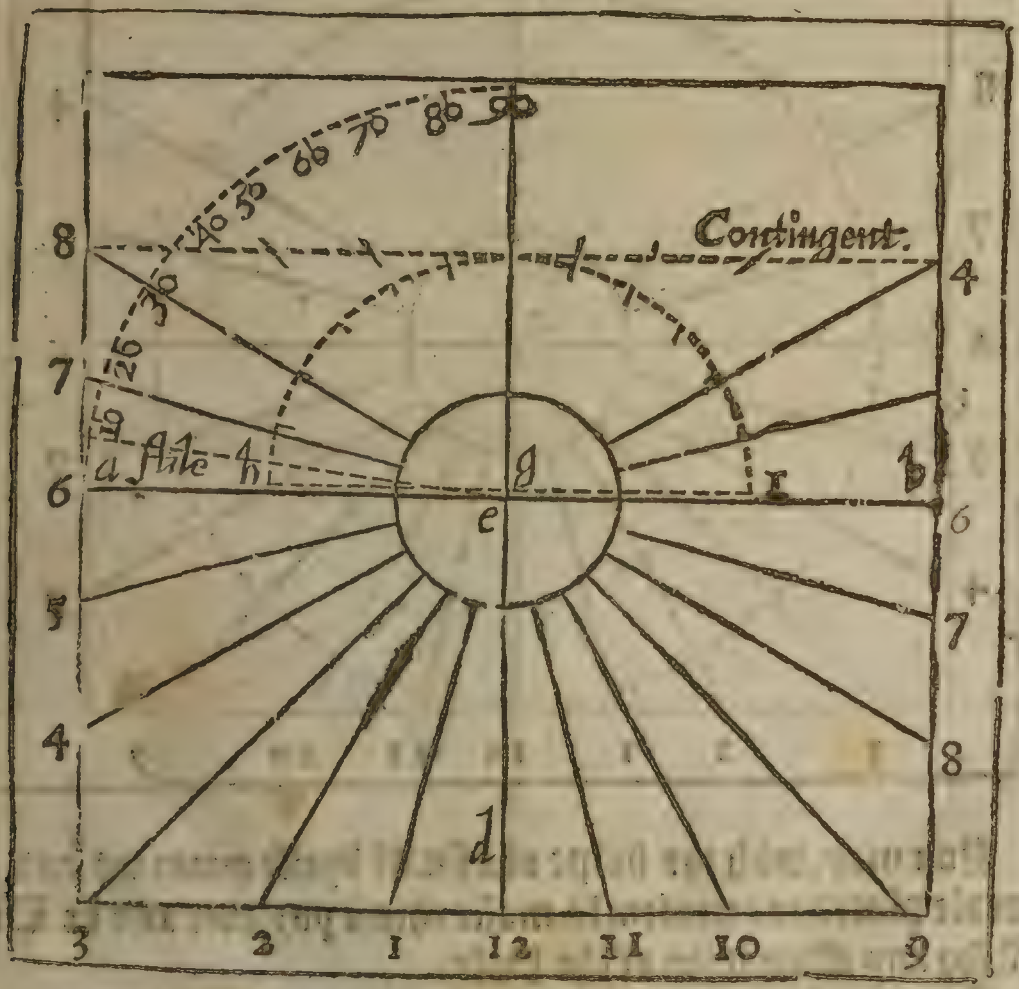
IN theſe kindes, if the Reclination be leſſe then the Elevation of the Pole, ſubtract that from this, and keepe the remainder for the Elevation of the Pole: according to which Elevation, make a North Diall Erect Direct and it will be fit for your plat. In which the houres about Noone are placed, being profitable onely in Summer: and not then, unleſſe the Reclination be greater then the diſtance of the Tropike of ♋: from the Zenith,

Zenith. And the more your Diall reclineth, the longer time it will ſhew in Summer.

Example of a North Diall Reclining 45. degrees.

FIrſt I take the Eleuation of the Pole (which wee account 52. d.) out of the Reclination of the plat, which is 45. d. and there remaine 7. d. which ſhall bee in place of the Eleuation of the Pole.

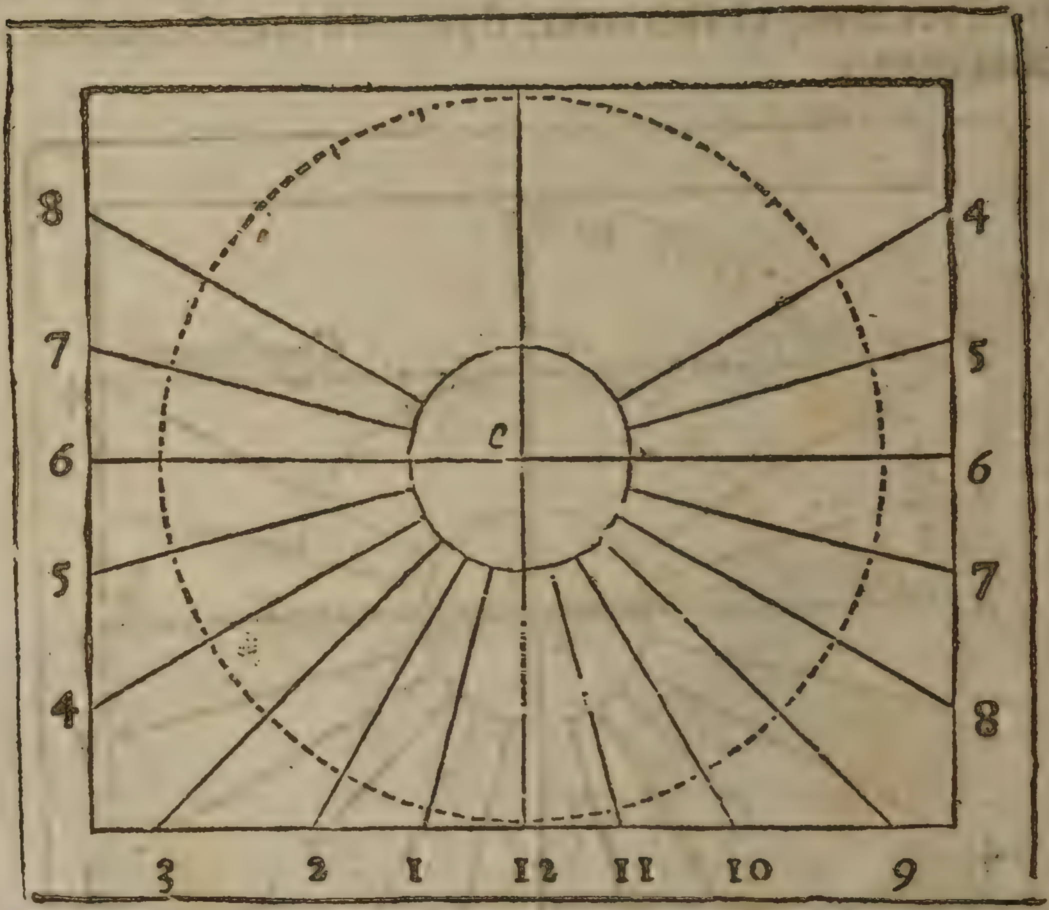
Then for the drawing of it, reſort to the North Erect Direct, becauſe their Delineation is like: remembring alwaies to call that which remaineth, the Eleuation of the Pole: which in this example is but 7. d. In the figure following you ſee, that moſt part of the houre lines be drawne oppoſite from the Contingent, beyond the centre E. as you muſt doe in any of this kinde, if you will haue the houres about noone.



Example of a North Diall Reclining 52. degrees.

But if the reclination be equall with the Eleuation of the Pole: then deſcribe a circle vpon the centre E.& diuide it into 24.equall parts, beginning the diuiſion at the 12.houre. Draw by thoſe points, lines for the houres from the centre E. ſo many as ſhall be neceſſary: erecting the Stile (being ſome ſmall wyer) in the centre E. right vp. This kinde of Diall ſerueth only when the Sunne is in the North ſignes, which be ♈,♉,♊,♋,♌,♍.

A North Reclining Direct.



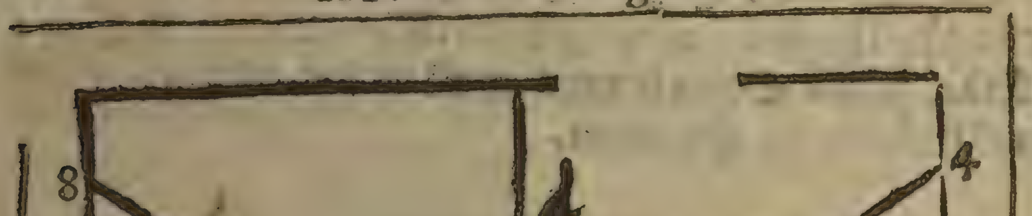
You may, with the helpe of a ſmall braſſe quadrant and a needle placed conueniently, make this a portable and fit Diall for any Eleuation of the Pole.

Againe, if the Reclination ſhall exceede the Eleuation of the Pole: adde the complement of the reclination to the Elevation, and with that number, as if it were the Elevation of the Pole, make your Diall altogether like a Horizontall, and it ſhall be fit for your plat. In which notwithſtanding in winter, very few houres ſhew, and thoſe about noone: and yet not theſe, unleſſe the reclination ſhall be greater, than the nigheſt bending of the Tropike ♑, from the Zenith.

Example of a North Diall reclining 80.^{d}.

First, adde the complement of the reclination of the plat which is 10, ^{d}. to the Elevation of the Pole 52. ^{d}. and with the totall number 62. ^{d}. as if it were the Elevation of the Pole, make a Horizontall Diall, as is ſhewed Chap. 3. Alwayes remember to call the two numbers added together, The Elevation of the Pole.

A North declining direct.



The

The making of an Eaſt and Weſt Diall reclining.

Chap. 13.

First, multiply the Sine of the elevation of the Pole, by the Sine of the Reclination of the plat, and divide the product by the whole Sine: whereof ſhall come a quotient, whoſe arke is the diſtance of the Stile from the Subſtile.

Compare the Complement of this diſtance with the Complemẽt of the Elevation of the Pole, and which you ſhall find leaſt, multiply the Sine thereof by the whole Sine, parting the product by the Sine of the greater. The quotient ſhal yeeld an Arke, whoſe Complement ſhall be the diſtance of the Subſtile from the Meridian.

Example of an Eaſt or Weſt Diall, reclining 45. degrees.

First I multiply the Sine of the Elevation of the Pole 52.^{d}.being 78801.by the Sine of the Reclination of the plat, which is 70710.and the Product 5572018710. I divide by 100000. the whole Sine & the quotient is 55720 the Arke whereof 33.^{d}.52.^{m}. which is the diſtance of the Subſtile from the Stile.

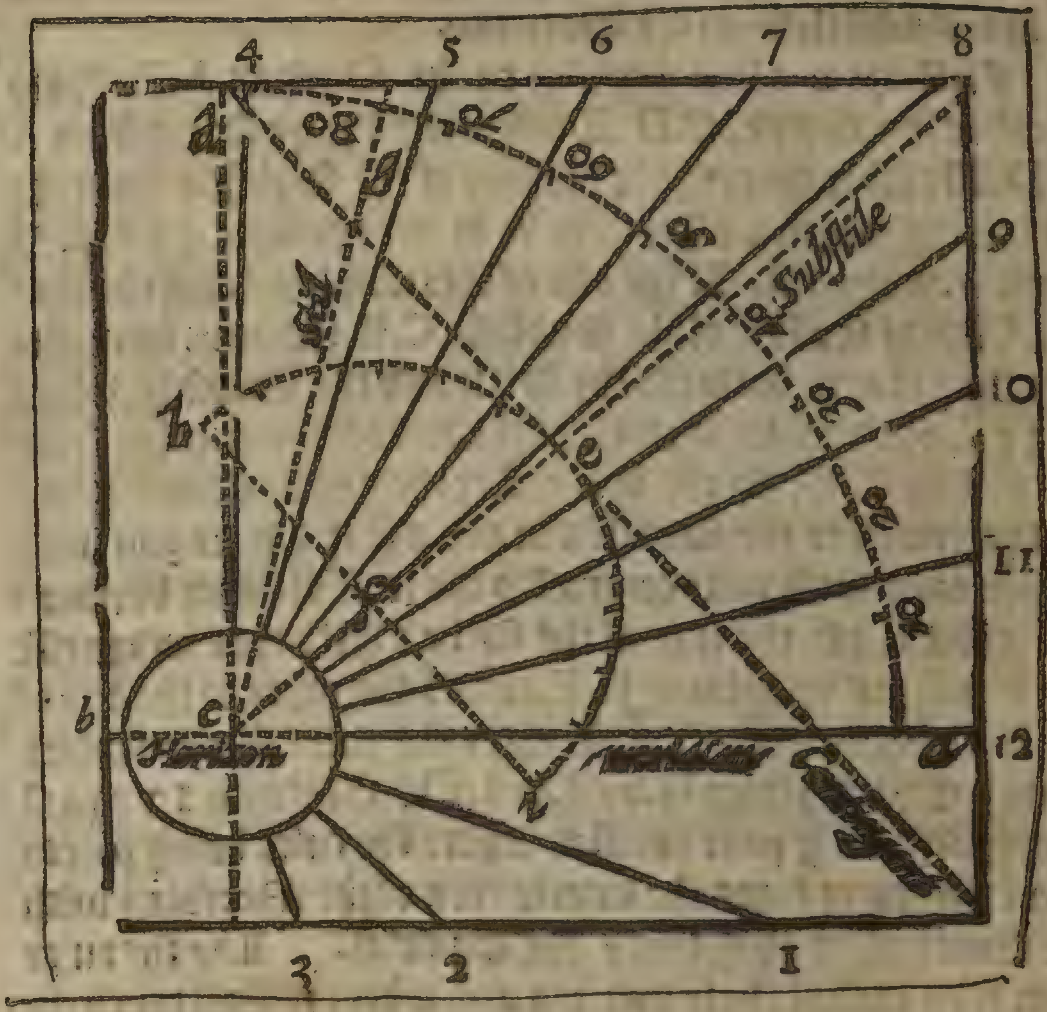
Then I compare the Complement af this diſtance which is 56.^{d}.8.^{m}. with the Complement of the Elevation of the Pole, which is 38.^{d}.and finding the Complement of the Elevation to be leaſt, I multiply 61566. the Sine thereof by the whole Sine: and the Product ariſing thereof is 6156600000: which I divide by the Sine of the greater, which is the Complement of the diſtance, whoſe Sine is 83033. And the Quotient 74141. yeeldeth an ark 47.^{d} 51.^{m} whoſe Complement is 42.^{d}.9^{m}. which is the diſtance of the Subſtile from the Meridian.

The delineation of the Figure.

Firſt draw a line parallel to the Horizon A. B. draw another ſquirewiſe, C.D. Then make the quadrant from A to D. Number therein the diſtance of the Subſtile from the Meridian (which we found to be in our example 42.^{d}.9.^{m}) from A. toward D. At the end of this number from the centre. C. draw the line of the Subſtile, C.E. Account from this line the diſtance between the Stile and the Subſtile, which is 33.^{d}.52.^{m}. draw likewiſe at the end of this number from C. the line C. G. for the Stile. Let the line of Contingence be ſquirewiſe to the Subſtile in any point where you will. Then take with your compaſſes the leaſt diſtance between the point E. and the line of the Stile: with that wideneſſe the one foote remaining in E. extend the other in the line of the Subſtile toward C. make there the point F. upon which draw ẏ Equator from H. by E. to I. Divide it into 12 equal parts; beginning your deviſion where the ruler being placed upon the centre F. and the interſection of the Meridian with the Contingent ſhall touch the Equator. Lay the ruler from F. by each of thoſe markes, and where it ſhall touch the line of Contingence, there make markes: by which from the centre C. draw the houre lines ſo many as ſhall be neceſſary. The line A.B. is the Meridian, and ſheweth the 12 houre. Finiſh al other things, as in the reſt before you were taught.

Note that if it be an Eaſt diall, you muſt make the quadrant from A. to D. If a Weſt, from B. to D. Finiſh the reſidue as before, &c.

An East or Weſt reclining.



The makiug of a South reclining declining Diall.

CHAP. 14

FIrſt, in this kind, as in other which follow, you muſt find out and place the Meridian, the Subſtile, and the Stile, which being done, that which remaineth is finiſhed as in thoſe before.

Therefore the Declination and the Reclination of the plat being known by your Inſtrument, multiply the Sine of the declination by the Sine of

the complement of the Reclination, dividing the product by the whole Sine. The quotient Sine ſhall yeeld an Arke, whoſe complement ſhall be named the Comple
repeated.

Afterward augment the Sine of the Complement of the Declination, by the whole Sine, divide the product by the Sine of the complement to be repeated: whereof ſhall come a ſign, whoſe Arke ſhall be the diſtance of the Meridian from the Horizon.

Againe multiply the Sine of this diſtance, by the Sine of the Complement of the Reclination, part the Product by the whole Sine, the Arke of whoſe quotient ſhall be called the Elevation of the Meridian.

Then compare this Elevation of the Meridian, with ye Elevation of the Pole, and which you ſhall find leaſt, ſubtract that from the greater, and that which remaineth keep, (for it ſhall be called the difference kept) being mindfull which of them was the greateſt.

This done multiply the Sine of the Complement to be repeated by the Sine of the difference kept; dividing the Product by the whole Sine, whereof ſhall come a Sine, whoſe ark ſhall be the diſtance of the ſtile from the ſubſtile:

To conclude, compare the Complement of this diſtance with the complement of the difference kept, and which you ſhall find leaſt, multiply the Sine thereof by the whole Sine: part the Product by the Sine of the greater, and thereof ſhall come a Sine, the Complement of whoſe Arke ſhall be the diſtance of the Subſtile from the Meridian.

Example of a South Diall { Declining 18.^{d}.
Reclining 25.^{d}.

Firſt looke out in the Table the Sine of the Declination which is 30901. Then the Complement of the Reclination being 65.^{d} the Sine hereof is 90630. Afterward multiply 90630. by 30901. and the product 28005 57630 divide the whole Sine, which is 100000. the quotient ſhal be 28005. whoſe arke is 16.^{d} 16.^{m} The Complement [illegible] 73.^{d} 44.^{m} is the Complement to be repeated.

This done, multiply 95105. the Sine of the Complement of the Declination 72. by the whole Sine 100000. the product ſhall be 9510500000. which being divided by 95996. the Sine of the complement to be repeated, yͤ quotient ſhal be 99071, whoſe arke is 82.^{d}.11.^{m}. which is the diſtance of the Meridian from the Horizon.

Afterward augment the Sine of this diſtance 99071. by the Sine of the complement of the Reclination, which is 90630 and the Product 8978804730. part by the whole Sine: and the quotient 89788. ſhal yeeld an arke 63^{d}.53^{m} which is the Elevation of the Meridian

Then compare the Elevation of the Meridian, with the Elevation of the Pole, which in this example is 52.^{d}. and finding the Elevation of the Pole to be leaſt, ſubſtract this (namely 52.^{d}.) from 63.^{d}.53.^{m}. the Elevation of the Meridian, & there remaineth 11.^{d}.53.^{m}. which is yͤ differēce kept

Now multiply 95996 being the Sine of the Complement to be repeated, which is 20591. the Product is 1976653636, which divided by the whole Sine, the quotient ſhall be 19766, whoſe arke 11.^{d}.24.^{m}. is the diſtance of the Stile from the Subſtile.

Then to conclude, the Complememt of this diſtance, which is 78.^{d}.36.^{m}. being compared with the Complement of the difference kept, which is 78.^{d}.7.^{m}. you ſhall find the Complement of this differnce kept to be leaſt, wherefore multiply 97856. the Sine thereof, by the whole Sine and the product 9785900000. part by the Sine of the greater to wit, of the complement of the diſtance of tye Stile from the Subſtile, which is 98027. the quotient ſhall be 99825 whoſe arke is 86.^{d}.37.^{m}. The complement whereof is 3.^{d}.23.^{m}. which is the diſtance of the Subſtile from the Meridian.

There be three ſundry kinds of theſe Dialls, the one differing from the other.

The firſt kind.

Marke therefore if the Elevation of the Meridian bee greater then the Elevation of the Pole, draw a line parallell to the Horizon A.B. out of the middeſt whereof extend another C.D. ſquirewiſe to the line A.B. make the quadrant from A. to D. number therein from A. towards. D. yͤ diſtance of the Meridian from the Horizon, which is 82.^{d}. 11.^{m}. at the end hereof at the centre C. draw the line C.E. for the Meridian.

From which account backward towards A. the diſtance of the Subſtile from the Meridian, which is 3.^{d}.23.^{m}. draw at the end of this number the line C.F. for the Subſtile.

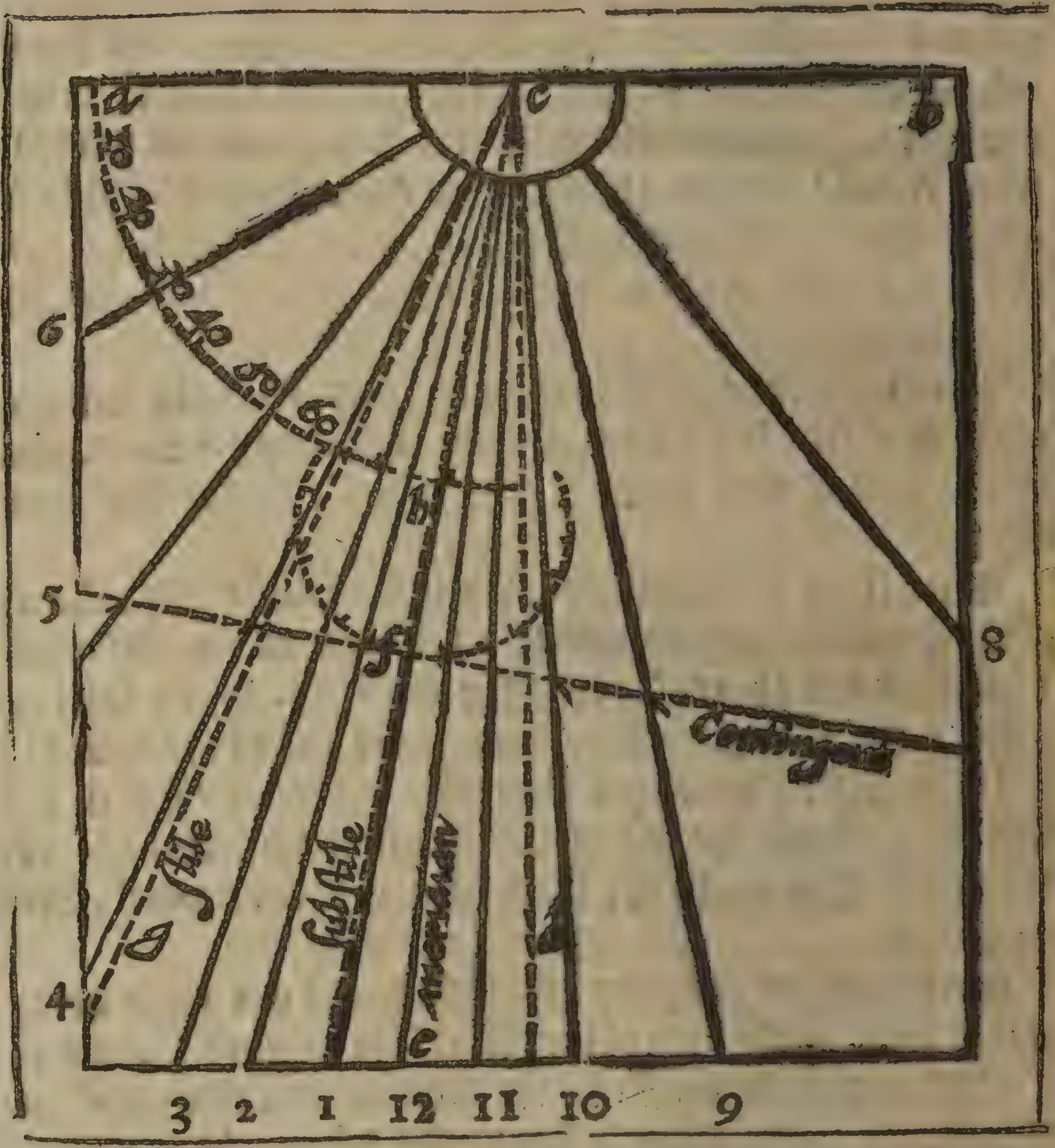
Then from the Subſtile toward A. number the diſtance of the Subſtile from the Stile 11 Degrees, 24. minutes, and at the end thereof extend the line C.G. which ſhall repreſent the Stile. This done in the line of the Subſtile in the point F. (which you may take where you will in the Subſtile) draw the line of Contingence ſquirewiſe to the Subſtile. Then take the leaſt diſtance of the point:F. from the Stile.

Afterward extend your compaſſes, the one foote being placed in F. in the line of the Subſtile toward C. unto H. Deſcribe upon the centre H. the Equinoctiall circle by F. divide it into 24. equall parts beginning where the ruler ſhall touch the Equator, being placed upon the centre H. and upon every marke of the Equator, and where the ruler ſhall touch the line of Contingence, there make markes, by which from the centre C. draw the houre lines ſo many as ſhall be neceſſary, C.E. alwayes ſhewing the 12 houre. Let the Stile hang directly over the Subſtile with ſo great an angle as F.C.G. is: fixing in the centre C. pointing

downe-downward to the Pole Antartick.

Place the line A.B. paralell to the Horizon, having afterward, as other preparative lines, no uſe.

A South declining reclining.



The ſecond Table.

But if the Elevation of the Pole, and the Elevation of the Meridian be found equall, the making of your Diall differeth from the former: yet the finding out of the Meridiā and the Subſtile. &c. is wrought as in the other before,

whether

whither you may reſort It ſhall be ſufficient here to ſhew an example of this kinde.

Example of a South Diall whoſe
Declination is, 32.^{d}.
Reclination is 33.^{d}.30.^{m}.
Elevation of the Pole is, 52.^{d}.2.^{m}.

Firſt, I multiply 52991 the Sine of the declination, by 83388 the Sine of the Complement of the Reclination, and the product 4481813508 ariſing thereof, I divide by the whole Sine: the quotient Sine 44188 yeeldeth an ark 26.^{d}.14.^{m}. whoſe complement being 63.^{d}.46.^{m}. is the complement to be repeated.

Then I increaſe the Sine of the Complement of the declination, which is 84804, by the whole Sine, and the product is, 8480400000: which I part by 89700, being the Sine of the Complement to be repeated. The arke of whoſe quotient Sine 94541 being 70.^{d}.59.^{m}, is the diſtance of the Meridian from the Horizon.

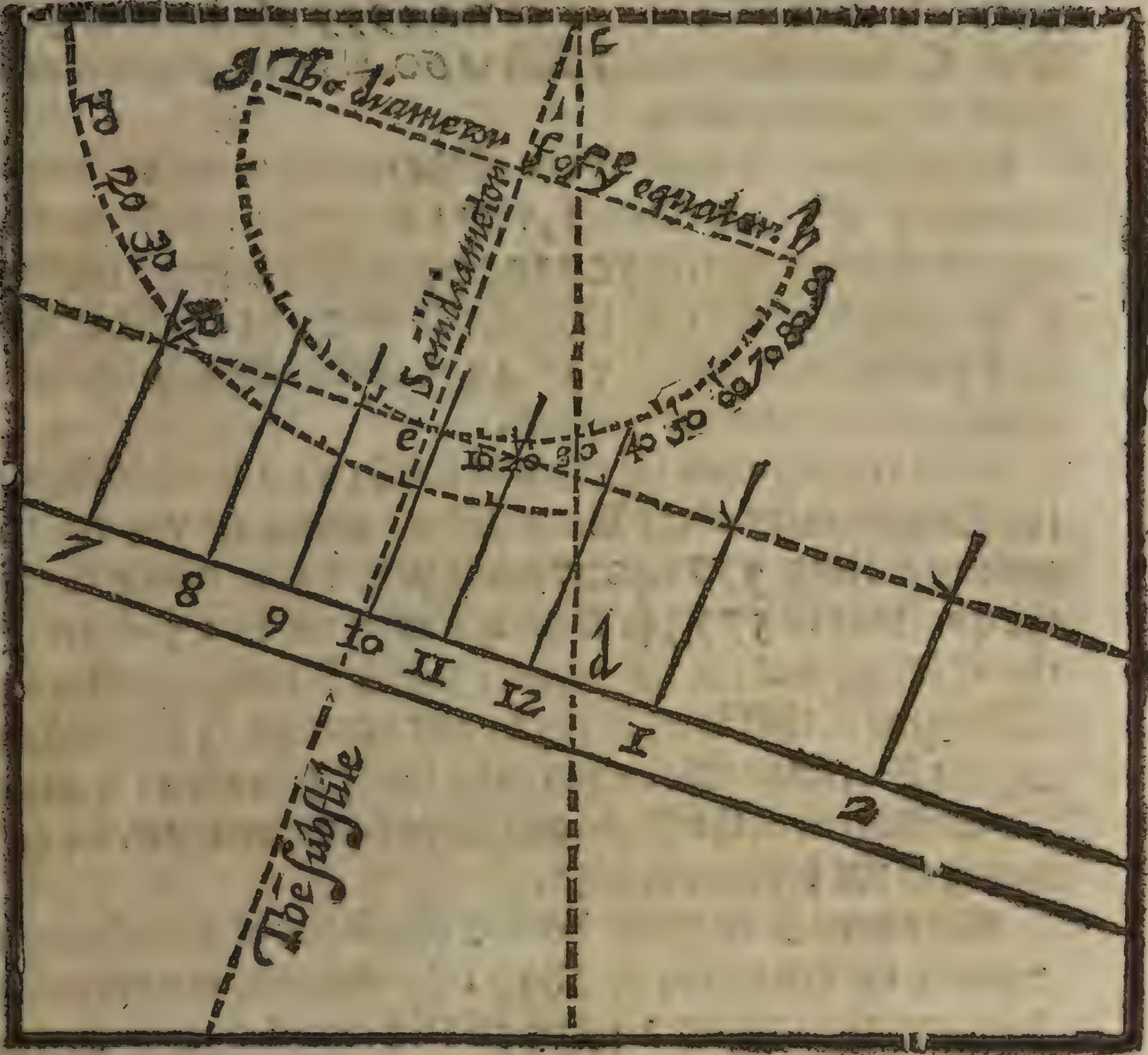
This done, I multiply this Sine 94541, by the Sine of the complement of the reclination, which is 83388, and the product ariſing hereof, being 7883584908, I divide by the whole Sine: yͤ quotient thereof is 78835. whoſe arke 52.^{d}.2.^{m}. is the Elevation of the Meridian, which I compare with the Elevation of the Pole, and finding them equall, I end my worke here. For this ſhall be ſufficient in this kinde of Diall, as you may more plainly perceive by the delineation of the Figure.

Wherefore if the Elevation of the Pole, and of the Meridian be found equall. (as in this example it is) make a line parallel to the Horizon A. B. Draw another C.D. making right angles with the line A.B. Draw the quadrant from A. to D. number therein the diſtance of the Meridian from the Horizon from A. toward D. which is 70.^{d}.59.^{m}. being here in place of the Subſtile. Then draw the line of Contingence ſquire-wiſe to the Meridian C.E. (which is alſo yͤ

Subſtile) C. E. in any point thereof, as before: Place one foote of your Compaſſes in the interſection E. then ſet the other foot in the Meridian (or Subſtile) being of any wideneſs make there the point or centre F upon which centre draw the half Equator from G by E to H. Diuide the one halfe therof from E. towards H. the declination of the plat 32.^{d}. place the ruler upon the centre F. and the end of this number, and where it ſhall touch the Contingent line, there make a marke, by this marke, you muſt draw a line ſquirewiſe to the Contingent line which ſhall be for the 12 houre And where the ruler ſhall touch the Equator, there begin to diuide it into 12 equall parts, by which lay the ruler from the the centre F. making in the line of Contingence markes for the other houre lines, all which ſhall cut the Contingent line ſquire-wiſe. Note ſomtime in diuiding of the Equator, the two parts at both ends next to the Semidiameter G.H ſhall both of them make but one whole part, unleſſe you will make a whole circle for the Equator and diuide it into 24 parts.

Let the Stile be a ſmall wyer ſtanding right up in the point E. being ſo long as the Semidiameter of the Equator. It may be alſo a plate of iron or braſſe faſtened in the Subſtile, ſo broad as the Semidiameter is, as in the Eaſt and Weſt erect Dials, &c. Let the line A.B. be paralell to the Horizon. Finiſh all other things as before.

A South reclining declining.



The third kinde.

If the Elevation of the Meridian be leſſe than the Elevation of the Pole, the making of this Diall is unlike to both the other mentione dbefore, yet the finding out of the diſtance of the Stile from the Subſtile, is done like to the firſt kinde, as by the example following may appeare.

Example of a South Diall {
Declining 45.^{d}.
Reclining 45.^{d}.
Elevation of the Pole 52.^{d}.

Firſt, I multiply the Sine of the declination, being 70710 by the Sine of the Complement of the reclination which is likewiſe 70710, and the product 4999904100 I part by the whole Sine. The quotient is 49999 whoſe ark is 30^{d} The Complement of this Ark is 60.^{d}. which is the Complement to be repeated.

Then I increaſe the Sine of the complement of the declination, which is likewiſe 70710, by the whole Sine, and the product thereof 7071000000 I devide by the ſine of the complement to be repeated 86602: the quotient ſine 81649 yeeldeth an ark 54^{d}.44^{m}. which is the diſtance of the Meridian from the Horizon.

Afterward I multiply this Sine 81649, by the Sine of the Complement of the Reclination, which is 70710. the product ariſing 5773400790 I part by the whole Sine, the quotient is 57734. The ark whereof is 35.^{d}.16,^{m}. the Elevation of the Meridian: which I compare with the Elevation of the Pole (being in our example) 52^{d}. and finding the Meridian Elevation to be leaſt, I ſubſtract it out of the Elevation of the Pole, and there remaineth 16.^{d}.44.^{m}. which is the difference kept.

This done, I augment 86602 the Sine of the Complement to be repeated, by 28791 the Sine of the difference kept, and the product 2493358182 comming hereof, I divide by the whole Sine, the quotient Sine 24933 yeeldeth an arke 14.^{d}.26.^{m}. the diſtance of the Stile from the Subſtile.

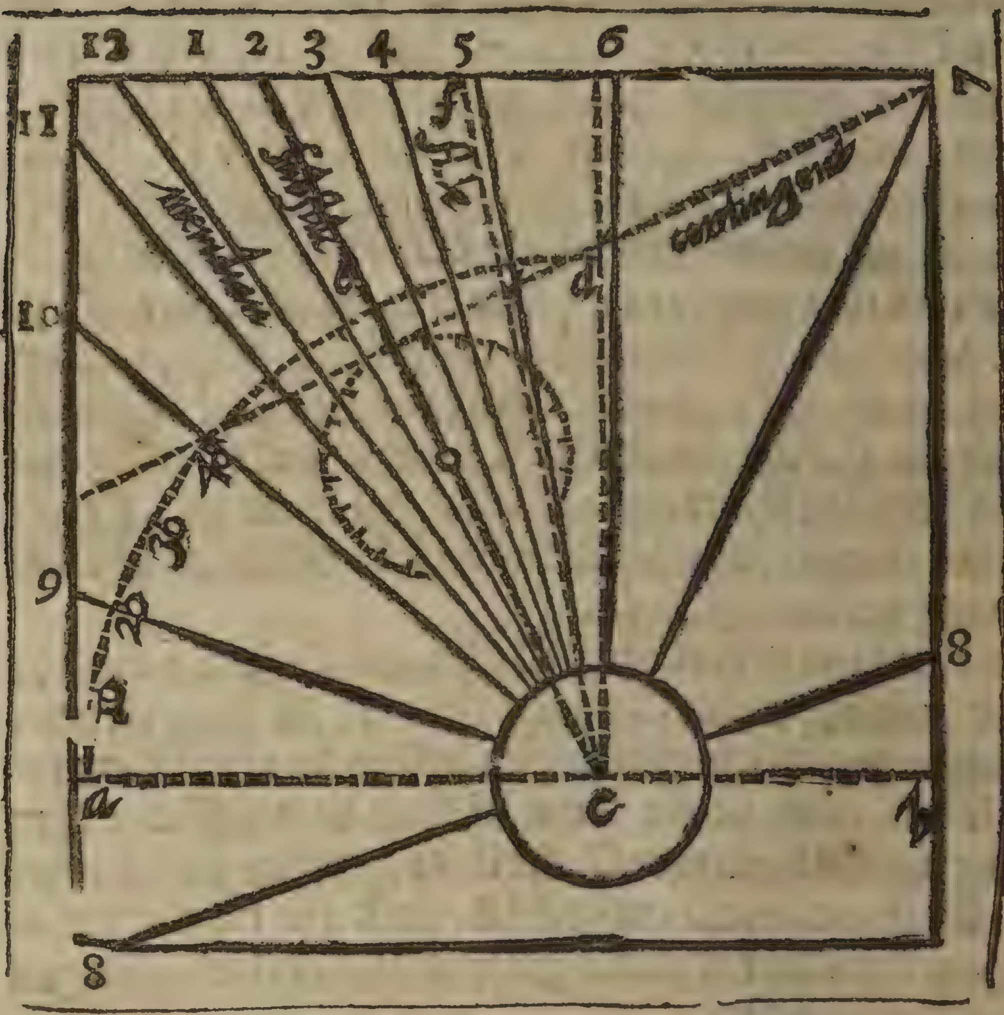
Now comparing the Complement of this diſtance being 75.^{d}.34.^{m}. with the Complement of the difference kept, which is 73.^{d}.16.^{m}. and ſeeing the Complement of the difference kept to be leaſt: I multiply 95765 the Sine thereof, by the whole Sine, and the product 9576500000 I divide by 96843. the Sine of the complement of the diſtance and 98886. ſhall be the quotient thereof, whoſe ark is 81.^{d}.27.^{m}. The Complement of this ark is 8.^{d}.33.^{m}. which is the diſtance of the ſubſtile from the Meridian.

In the delineation of this Diall, draw firſt as before a line Parallel to the Horizon A.B. extend another C.D. making right angles with the line A.B. Draw the Quadrant from A. to D. divide it into 90 degrees. In what account the diſtance of the Meridian from the Horizon, from A. towards D. which is 54.^{d}.44.m. draw at the end of this number the Meridian line from the centre C. which ſhall ſhew the 12. houre. Account from this toward D. the diſtance of the Subſtile from the Meridian, which is 8.^{d}.33. m. at the end hereof extend from C. the line E. for the Subſtile. From this number the diſtance of the Stile being 14.^{d}.26.^{m}. towards D. if there be ſo much ſpace, if not, account it from the Subſtile toward A. make at the end of this number the line C.F. for the Stile. Let the line of Contingence cut the Subſtile ſquire-wiſe, in what point you will. Finiſh all other things, as in the firſt of theſe three kindes of ſouth reclining declining Dials.

In this kind of reclining Dials, whoſe Stile muſt be placed from the centre C. upward toward the Pole Artike: if at any time you cannot draw to both ends of the Contingent line ſo many houre lines as ſhall be neceſſary: then prolong beyond the centre C. the lines oppoſite on the other ſide. As if you would make the 8. hour line for the morning, draw the 8. for the evening beyond the centre C. and you ſhall have your deſire.

Note that moreover, in this kind contrary to the other before, if the plat decline toward the Weſt, (as in this example it doth) Then draw the quadrant toward the Weſt, &c. But if the Declination be towards the Eaſt, make the quadrant toward the Eaſt.

A South reclining declining.



The making of a North reclining declining Diall.

CHAP. 15.

The firſt kind.

IN this kind, as in the South before: firſt, multiply the Sine of the declination, by the Sine of the Complement of the reclination: parting the product by the whole Sine. The Quotient Sine thereof ſhall bee an Ark, whoſe Complement ſhall be called the Complement repeated.

Then increaſe in the Sine of the complement of the Declination by the whole Sine, divide the product by the ſine of the Complement repeated: the quotient Sine thereof will give an Arke, which ſhall be the diſtance of the Meridian from the Horizon.

The ſame quotient Sine multiply by the Sine of the Complement of the reclination: and the number ariſing part by the whole Sine: the Arke of this quotient is the Elevation of the Meridian.

Now adde the Elevation of the Pole to the Elevation of the Meridian and the totall number or Arke hereof, wee will call the compounded Arke. And if the compounded Ark be leſſe then 90 degrees: then multiply the Sine thereof, by the Sine of yͤ Complement repeated, dividing the product by the whole Sine: and hereof ſhall ariſe a quotient Sine, whoſe arke ſhal be yͤ diſtance of the Stile from the Subſtile

Now compare the Complement of this diſtance, with the Complement of the compounded Arke: and increaſe the Sine of the leſſe by the whole Sine, part the Product by the Sine of the greater: and thereof ſhall come a Sine, the Complement of whoſe Ark ſhall be the diſtance of the Subſtile from the Meridian.

But mark here the Diverſity which doth ariſe by reaſon of the compounded Ark: for hereby you ſhall have three ſundry wayes, both in finding out the diſtances between the Meridian and the Horizon, the Stile and Subſtile &c. And likewiſe in the Declination of the figure. Whereof ariſeth three ſundry kinds of Dials: the firſt of them being already taught.

The ſecond kind.

If the compounded Arke be iuſt 90 degrees: then the diſtnace of the Stile from the Subſtile ſhall be the Complement repeated: and the diſtance of the Subſtile from the Meridian ſhall be alſo 90 degrees

Note that in the working hereof, there is no difference from the firſt kind. For here, as in the other before, you ſhall firſt find out the complement repeated: then the diſtance of the Meridian from the Horizon: Afterward the Elevation of the Meridian, which being added to the Elevation of the Pole, if the totall number be iuſt 90.^{d}.you ſhall not need to proceed forward, for this (as before I made mention) ſhall be the diſtance of the Meridian from the Subſtile.

In this kinde you ſhall have no interſection of the Meridian and the Contingent line: therefore you ſhall begin the diviſion of the Equator at the line of the Subſtile, which ſhall ſhew the 6. houre, either in the morning or evening according as the plat doth decline.

The third kind.

But if the compounded Ark be greater than 90.degrees ſubſtract it from 180,and that which remaineth ſhall be called the difference kept. Then multiply the Sine of the complement repeated, by the Sine of the difference kept dividing the Product by the whole Sine, hereof ſhall come a Sine, whoſe Arke ſhall be the diſtance of the Stile from the Subſtile.

Then compare the Complement of this diſtance with the Complement of the difference kept, increaſing the Sine of the leſſer by the whole Sine, and parting the product by the Sine of the greater: whereof ſhall come a Sine, the complement of whoſe arke, being taken from 180. degrees the remainder ſhall ſhew how much the line of the Subſtile muſt be diſtant (upward by the Horizon) from the Meridian. For the better underſtanding of theſe three kindes, marke theſe three examples following, with the delineation of their figures.

Example of a North Diall whoſe
Declination is, 45^{d}.
Reclination 45.^{d}.
Elevation of the Pole, 52.^{d}.

Firſt, I worke this altogether like to the South reclining 45.^{d}. declining 45.^{d}. untill I have found out the Elevation of the Meridian.

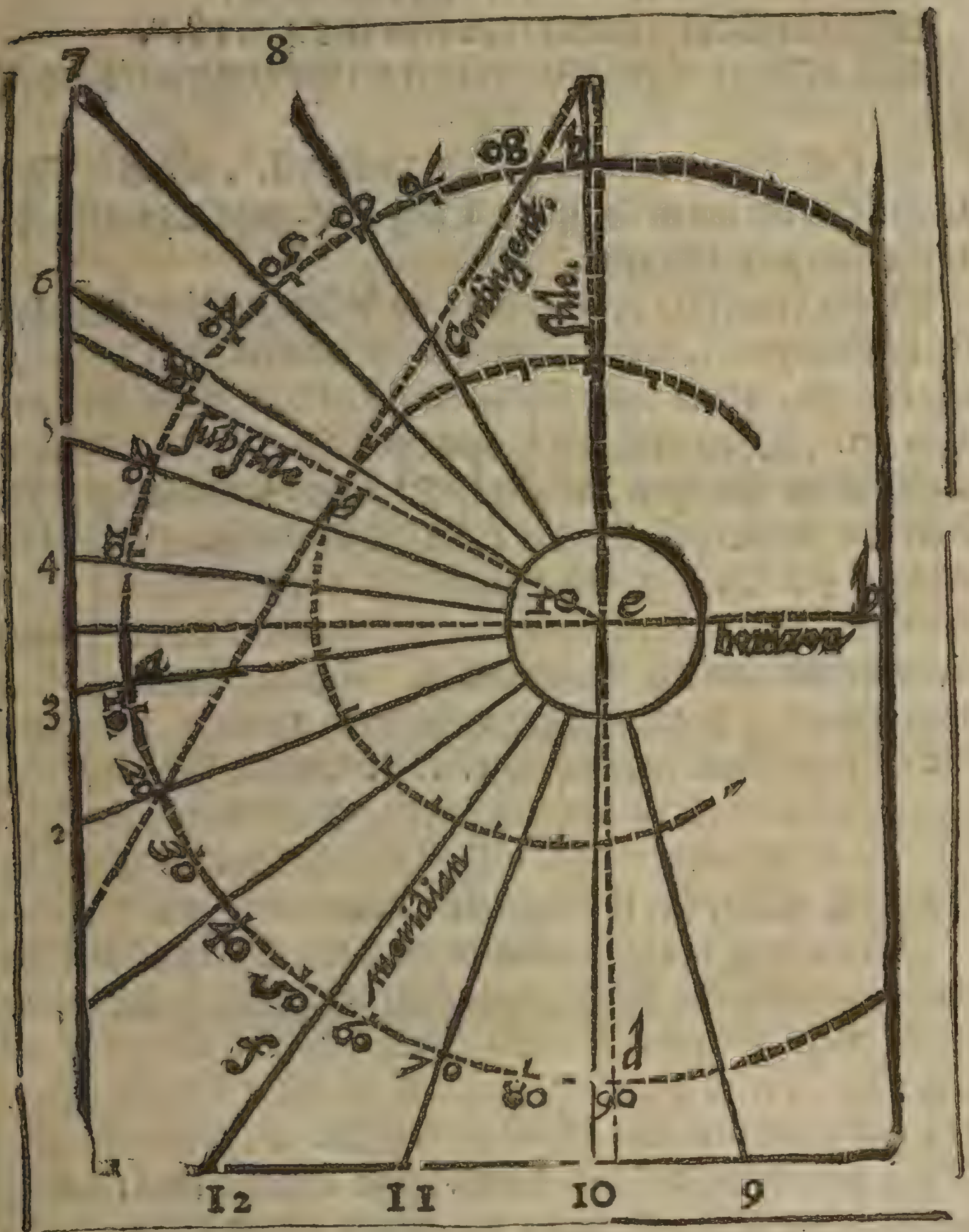
Then I adde the Elevation of the Meridian which is, 35.^{d}.16.^{m}. to the Elevation of the Pole 52.^{d}. the totall number is 87.^{d}.16.^{m}. which is the compounded arke: and being leſſe than 90.^{d}. I proceed with this arke, &c.

Now therefore I multiply the Sign of this compounded arke, which is 99884, by the Sign of the complement to be repeated being 86602 and yͤ product 8650154168 I part by the whole Sine. The quotient thereof is 86501, whoſe ark 59.^{d}.54.^{m}. is the diſtance betweene the Stile and the Subſtile.

Then I compare 30.^{d}.6.^{m}. being the Complement of this diſtance with the Complement of yͤ compounded ark which is 2.^{d}.44.^{m}. and finding this leaſt, I increaſe 4768 the Sign thereof, by the whole Sign, dividing the product which is 476800000, by 50151 the Sign of the greater: yͤ quotient Sine yeeldeth an ark 5.^{d}.27.^{m}. the Complement hereof 84.^{d}.33.^{m}. is the diſtance of the Subſtile from the Meridian.

In the drawing of this Diall, firſt as before, make a line parallel to the Horizon A.B. Then extend the line C.D. cutting the other ſquire-wiſe. Mark the interſection or centre with E. draw thereupon a circle A.B.C.D. whoſe two quadrants at the leaſt, toward A. (if the plat decline Weſtward, or elſe toward B. if it decline Eaſtward) being divided into 90.^{d}. each of them, number therein from H. towards D. the diſtance of the Meridian from the Horizon which is 54.^{d}.44.^{m}. and at the end hereof from the centre B. draw the line F. for the Meridian, or 12 houre. Account from this upward toward C, the diſtance of the Subſtile from the Meridian, being 84.^{d}.33.^{m}. make likewiſe at the end of this number from E. the line for the Subſtile. Again number from hence upward (if there be ſo much ſpace, or elſe downward) 59.^{d}.54.^{m}. which is the diſtance betweene the Stile and the Subſtile, and at the end hereof draw the line H. for the Stile. Let the Contingent line cut the Subſtile ſquire-wiſe in the point G. which you may take in any place of the Subſtile. Then with your compaſſes the leaſt diſtance of this point G. and the Stile being taken, with that wideneſſe extend them forth in the line of the ſubſtile toward E. making there the point I. upon which draw the Equator or Equinoctiall circle. This done, place the ruler upon the centre I. and the interſection of the Meridian and the contingent line, and where it ſhall touch yͤ Equator there begin to divide it into 24. equall parts. Finiſh all other things, as in thoſe which went before.

A North reclining declining.



The ſecond kind of North Diall, reclining 45. degrees 14. minutes, declining 38 degrees.

IT ſhall not be neceſſary to ſhew an example of this ſecond kinde, becauſe the Complement repeated, the diſtance of the Meridian from the Subſtile, and between the Stile and Subſtile, &c. is found out altogether like to the other before, and that which followeth. Therfore it ſufficeth to ſet down the number of the diſtances.

Firſt, the Complement repeated is $64.^{d}.18.^{m}$.

The diſtance of the Meridian from the Horizon is $60.^{d}$ $59.^{m}$.

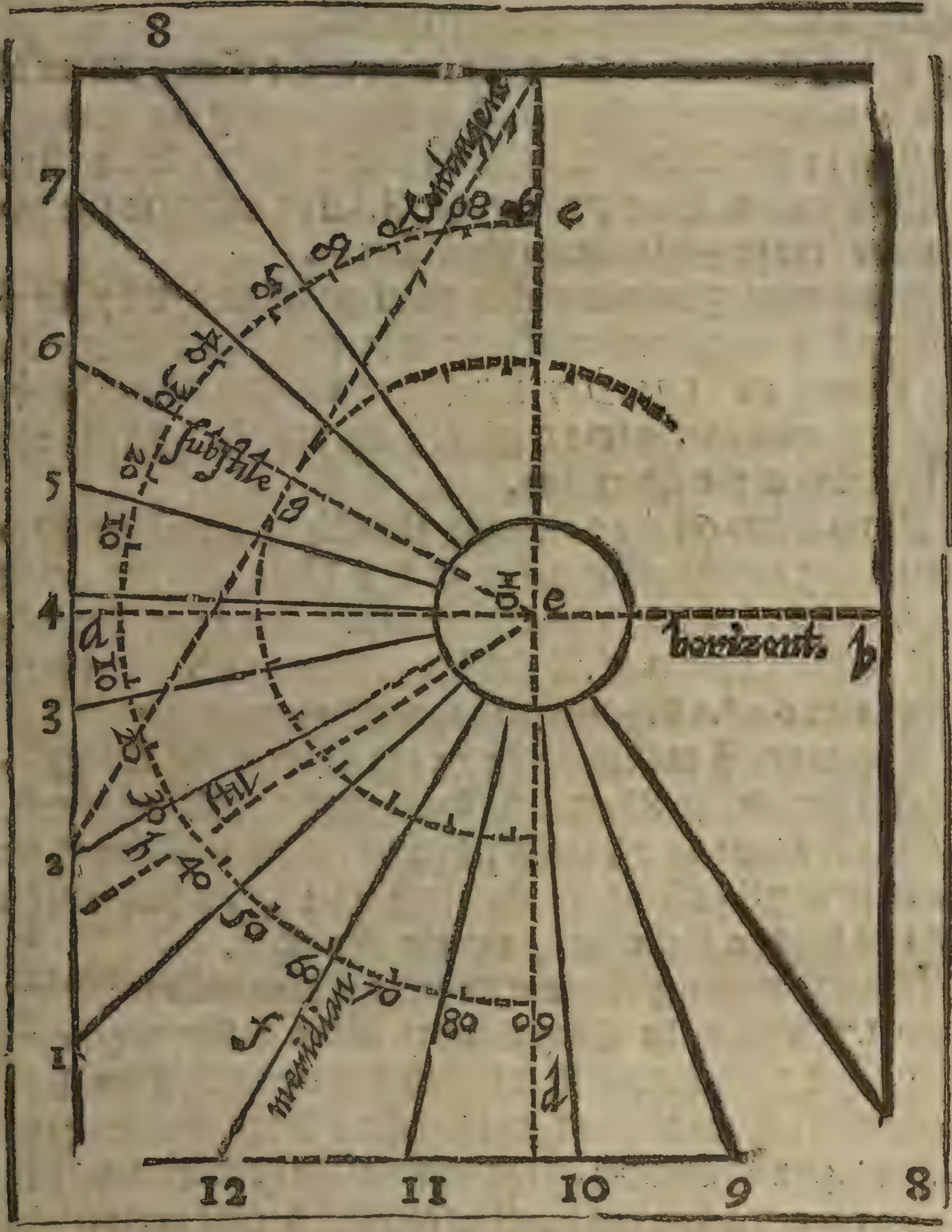
The Elevation of the Meridian is, $38.^{d}$ which I adde to the Elevation of the Pole being $52.^{d}$ and the totall $90.^{d}$ is the compounded arke.

Draw therefore in this kind as before, a line parallel to the Horizon A.B. make another ſquirewiſe, C.D. Draw the two quadrants from C. by A. to D. dividing each of them into $90.^{d}$. Then number herein the diſtance of the Meridian from the Horizon, which is $60.^{d}.59.^{m}$. drawing from E. at the end hereof, the line F. for the Meridian. From this account $90.^{d}$. being here the diſtance of the Subſtile from the Meridian: and likewiſe at the end of this number from E. draw the line for the Subſtile. Againe from this line downeward, (becauſe there is no ſpace upward,) account the Complement repeated $64.^{d}.18.^{m}$. which here we take for the diſtance of the Stile from the Subſtile: make likewiſe by this number the line E.H. for the Stile. Let the Contingent line cut the Subſtile ſquire-wiſe in any place.

Then taking the leaſt diſtance with the Compaſſes of the point G. and of the Stile, with that wideneſſe in the Subſtile, make the point I. upon which draw the Equinoctiall circle by G. And becauſe here (as in all other Dials where the compounded arke is iuſt $9.^{d}$. there is no interſection of the Meridian, and the Contingent line thereof: being the diviſion of the Equator 24 equall parts at the Subſtile, which in this kind ſhall ſhew the ſixth houre, either in the evening or morning, according to the declination of the plat. Place the ruler upon the centre I. and ſo many of theſe parts as you can, making marks in the line of Contingence as before, draw the houre lines by them, &c. finiſh the reſt as in the other.

A North

A North declining reclining:



Example of the third kinde of North Diall before-mentioned. { Reclining, 21.d.30.m. Declining. 30.d.

Here firſt, as before I multiply the Sign of the Declination being 50000,93041 which is the Sign of the complement of the reclination and yͤ product 4652070000 I part by the whole Sine: the quotient 46520 yeeldeth, an arke 27.^{d}.43.^{m}. The complement whereof is 62.^{d}.17.^{m}. being the Complement to be repeated.

Then I increaſe 86602 the Sine of the Complement of the Declination by the whole Sine, dividing the product, by 88525 the Sine of the Complement repeated: The Ark of the quotient Sine 97827, is 78.^{d}.2.^{m}. which is the diſtance of the meridian from the Horizon.

This done, I augment this quotient Sine 97827, by yͤ Sine of the complement of the reclination, which is 93041 the product 9101921907 I diſtribute by the whole Sine: and the quotient 91019 giveth an ark 65.^{d}.32.^{m}. the Elevation of the Meridian.

Now I add 65.^{d}.32.^{m}. being the Elevation of the Meridian to 52.^{d}. the Elevation of the Pole, and the totall number 17.^{d}.32.^{m}. being the compounded arke, becauſe it is greater than 90.^{d}. I ſubſtract it from 180, and there remaineth 62.^{d}.28.^{m}. which is the difference kept.

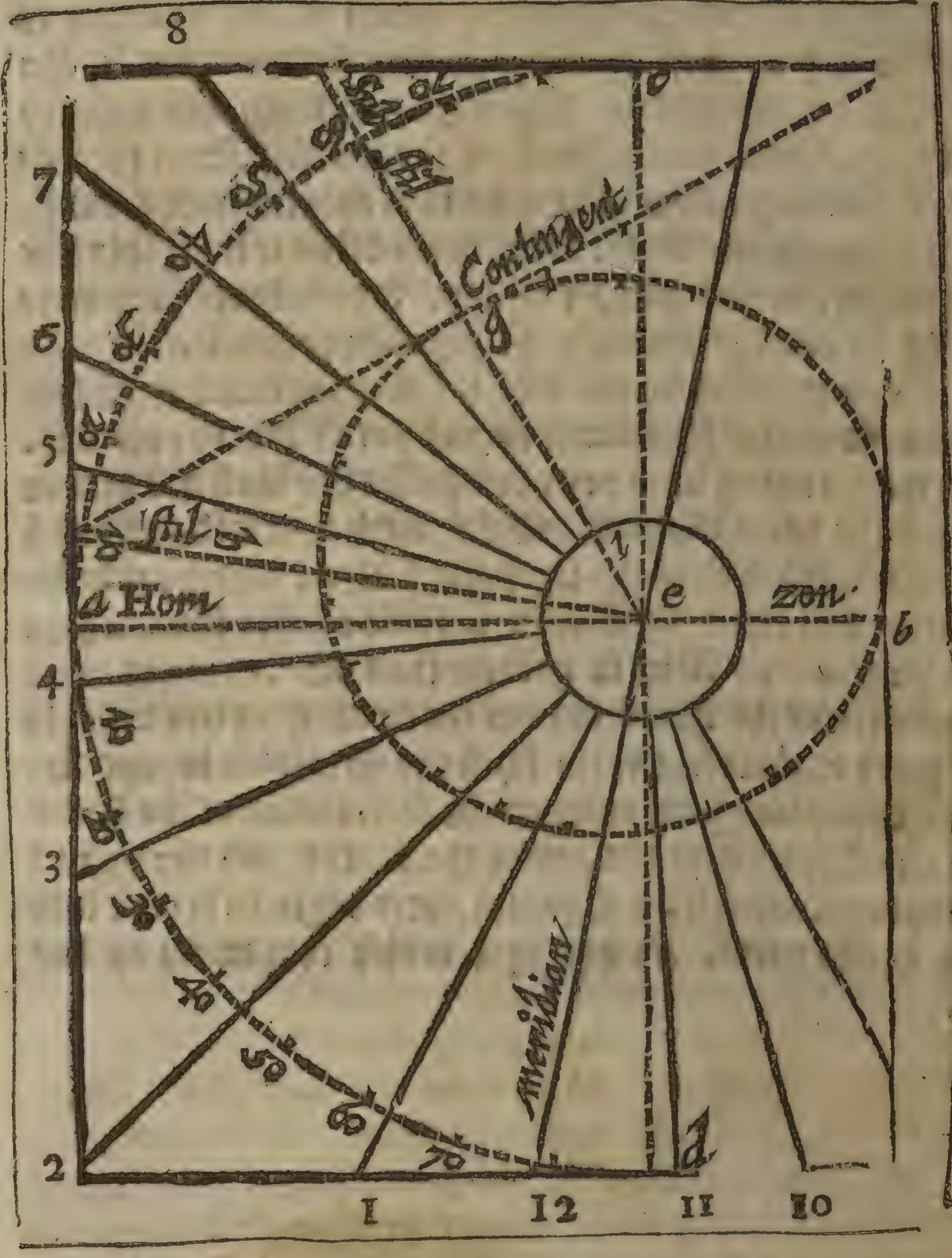
Afterward I multiply 88525 the Sine of the Complement repeated, by 88674 the Sine of the difference kept, parting the product 7849865850 by the whole Sine. The quotient is 78498 whoſe Ark is 51.^{d}.43.^{m}. which is the diſtance betweene the Stile and the Subſtile.

Then comparing the complement of this diſtance, being 38.^{d}.17.^{m}. with the Complement of the difference kept, which is 27.^{d}.32.^{m}. and finding this to be leaſt, I amplifie 46226 the Sine thereof by the whole Sine, dividing the product 4622500000 by the Sine of the greater, which is 61955 and 74612 the quotient coming hereof yeeldeth an arke 48.^{d}.15.^{m}. whoſe Complement being 41.^{d}45.^{m}. I take out of 180, and the remainder is 138.^{d}.15.^{m}. the diſtance of the Subſtile from the Meridian.

The delineation of the Figure.

Firſt, as before, draw a line A.B. parallel to the Horizon. Make another C.D. ſquire-wiſe to the former. Draw two quadrants at the leaſt C.A.D. dividing each of them into 90.^{d}. number therein from A. toward D. the diſtance of the Meridian from the Horizon, which in our example is found to be 78.^{d}.2.^{m}. draw at the end hereof from E. the line F. for the Meridian. Then account from this upward 138.^{d}.15.^{m}. being the diſtance of the Subſtile from the meridian, drawing likewiſe at the end of this number from E. the line for the Subſtile. Afterward account from this line (on which ſide you will) 51.^{d}.43.^{m}. the diſtance betweene the Stile and the Subſtile, extending the line E.H. by the end of this number for the Stile. Let the contingent line cut the Subſtile ſquirewiſe in any point where you will. Afterward taking with your compaſſes the leaſt diſtance betweene the point G. and the Stile, with that wideneſſe in yͤ Subſtile toward E. make the point I. upon which draw the Equinoctiall circle by G. And becauſe in this kind, where the compounded Arke is greater than 90.^{d}. there is none interſection of the Meridian and the contingent line beneath the centre E. therefore draw forth the Meridian beyond the centre, then place your ruler on the interſection of the Meridian and Contingent line above the centre, and the point I and where it cutteth the Equator, there begin to divide it into 24 equall parts. Finiſh that which remaineth as before.

A North reclining declining.



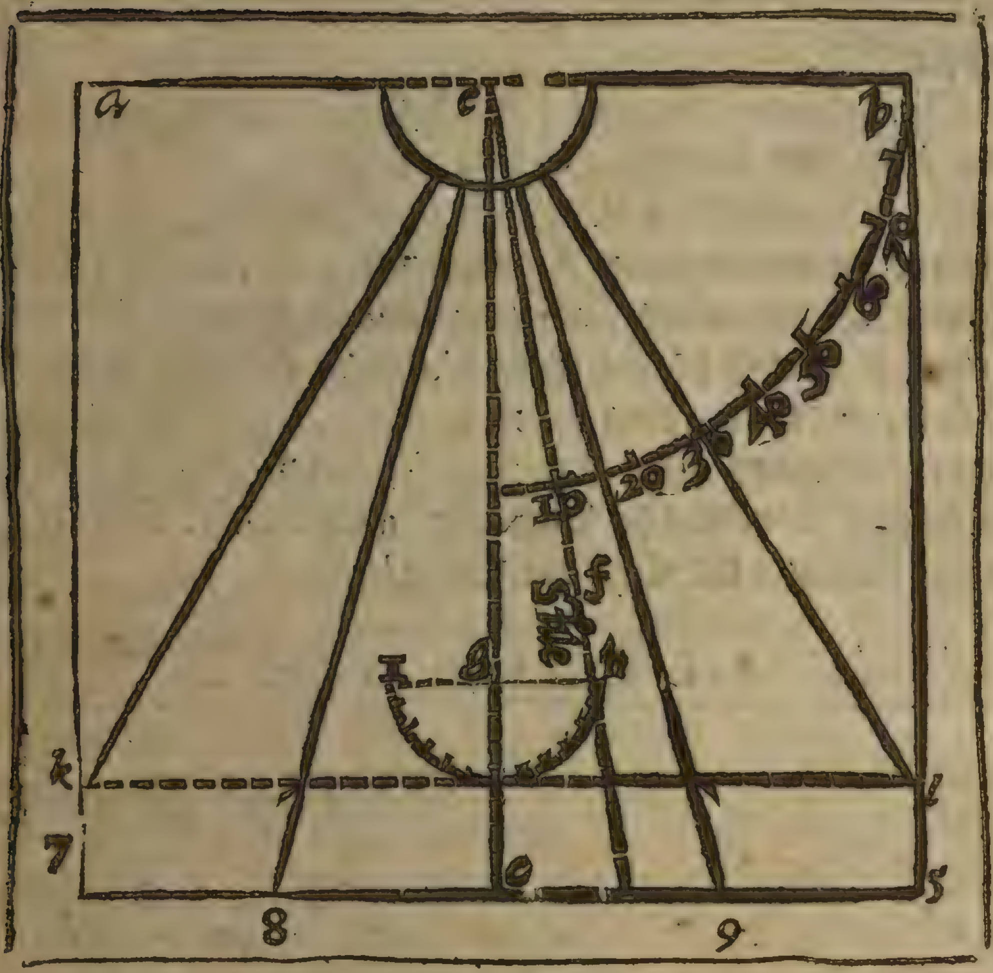
The making of a South Inclining direct Diall.

CHAP. 16.

If the inclination of the plat be leſſe than the Elevation of the Pole, take that from this, accounting the remainder for ẏ elevation of the Pole. And with this number as if it

were

A North inclining Direct.



The making of the Eaſt and weſt incliniug Dials.

CHAP. 18.

Multiply the Sine of the Elevation of the Pole by the Sine of the Inclination of the plac dividing the product by the whole Sine: the quotient arke ſhall be the diſtance of the Stile from the Subſtile.

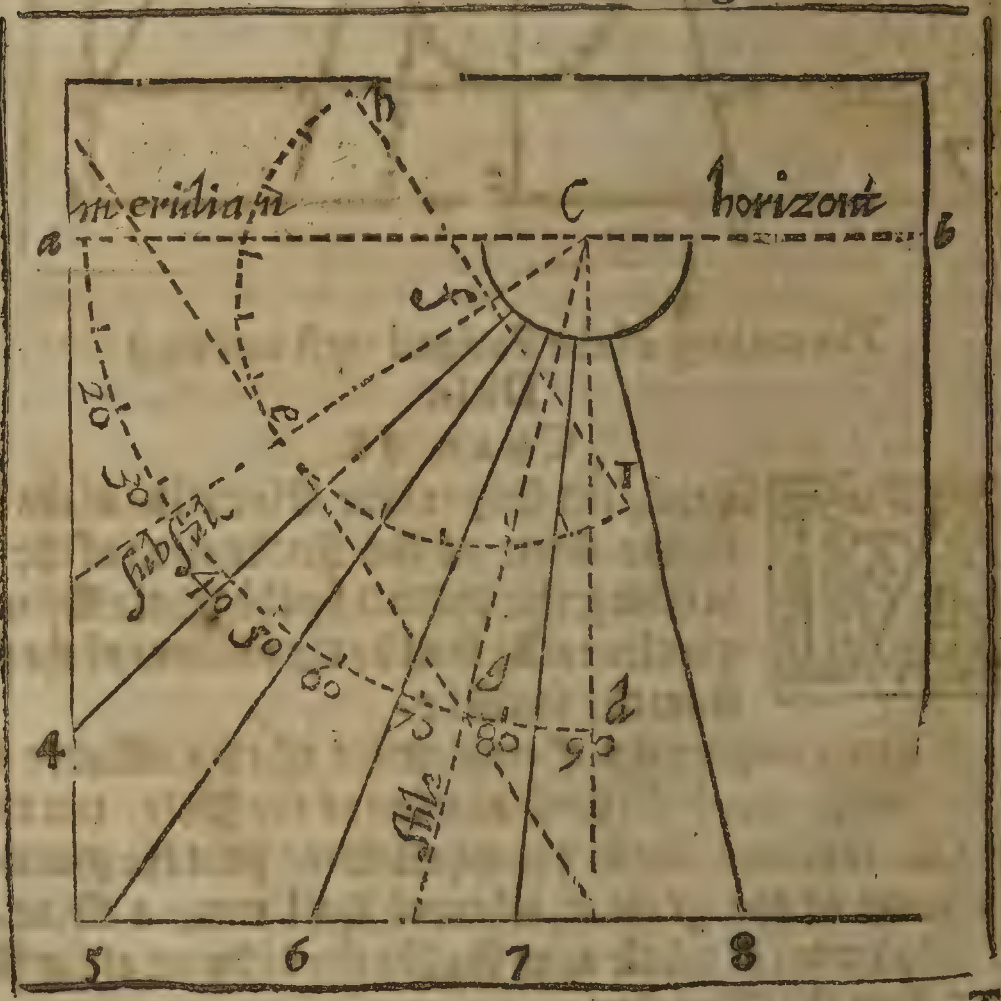
Then compare the Complement of this diſtance with the Complement of the Elevation of the Pole, increaſing the Sine of the leſſer by the whole Sine part the product by th Sine of the greater, whereof ſhall come a Sine, the Complement of whoſe arke ſhall be the diſtance of the Subſtile from the Meridian.

It ſhall not be neceſſary to ſhew any example hereof, becauſe the Eaſt and Weſt reclining bee altogether like unto this. Wherefore reſort thither, for the working of your example for thoſe diſtances in drawing this figure ſhall bee here obſerved.

The delineation of an Eaſt Diall, inclining 45.^{d}.

Firſt, draw a line Parallel to the Horizon, A.B. make the perpendicular line C. D. ſpuire-wiſe to the other. Deſcribe the quadrant from A, to D. number from A. toward D. 33.^{d}.52.^{m}. the diſtance of thr Subſtile from the Meridian, and at the end hereof from C. draw the line E. for the Subſtile, account from this 42.^{d}.9.^{m}. drawing likewiſe at the end of this number the line G. for the Stile. Let the Contingent line cut the Subſtile ſquire-wiſe. Finiſh all things elſe as in the Eaſt reclining.

An Eaſt and Weſt inclining.



The making of a South inclining declining Diall.

CHAP. 19.

First, multiply the Sine of the Declination, by the Sine of the Complement of the Inclination, parting the product by the whole Sine. The quotient Sine ſhall yeeld an arke, whoſe Complement ſhall be named the Complement repeated.

Then increaſe the Sine of the Complement of the Declination by the whole Sine: and the product divide by the Sine of the Complement repeated: whereof ſhall come a Sine, whoſe arke is the diſtance of the Meridian from the Horizon.

Afterward, this Sine being multiplyed by the Sine of the Complement of the Inclination, and the product parted by the whole Sine: the arke of the quotient Sine ſhall bee the Elevation of the Meridian. Which arke you muſt adde to the Elevation of the Pole. And if the totall number bee leſſe than $90.^{d}$ it ſhall be named the Doubtfull Arke. But if it be greater than $90.^{d}$ take it from 180, and let the remainder be called the Doubtfall Arke.

This done, augment the Sine of the Complement repeated, by the Sine of the doubtfull Arke: an the product ariſing thereof being divided by the whole Sine, the quotient Arke ſhall be the diſtance of the Stile from the Subſtile.

Now compare the Complement of this diſtance, with the Complement of the Doubtfull Arke, multiplying the Sine of the leſſer, by the whole Sine, dividing the product by the Sine of the greater: the Arke of the quotient Sine coming thereof ſhall be the diſtance of the Subſtile from the Meridian.

But note, if the doubtfull arke be found without ſubtraction from 180, (which is if it be leſſe than 90.^{d} then you muſt ſubtract the diſtance of the Subſtile from the Meridian out of 180. and the number remaining, ſhall be the true diſtance of the Meridian from the Subſtile.

Marke this likewiſe, if the doubtfull arke be equall 90. degrees, let the Complement repeated be the diſtance of the Stile from the Subſtile: then ſhall there be juſt 90.^{d}. for the ſpace betweene the Subſtile and the Meridian as before is taught in the North declining reclining, whither you may reſort for the working hereof. Here it ſhall be ſufficient to ſhew two examples, with the delineation of their figures: the one, where the doubtfull Arke is ſubtracted from 180.^{d}. and the other, where there is no ſubtraction hereof, becauſe it is leſſe than 90. degrees.

Example of a South Diall { Inclining 45. degrees.
Declining 45. degrees.

Foraſmuch as this is altogether like to the North reclining 45.^{d}. declining 45.^{d}. whither you may reſort: I will omit the working of the former part of this example, untill I come to the finding out of the diſtance of the Subſtile from the Meridian. The former part of this example you may find to be thus wrought in the North reclining declining.

First the Complement repeated 60.^{d}.

2 Then, the diſtance of the Meridian to the Horzion 54.^{d}.44.^{m}.

3 Next the Elevation of the Meridian 35.^{d}.16.^{m}.

4 The compounded Arke there, which we call the doubtfull Arke here 87.^{d}.16.^{m}.

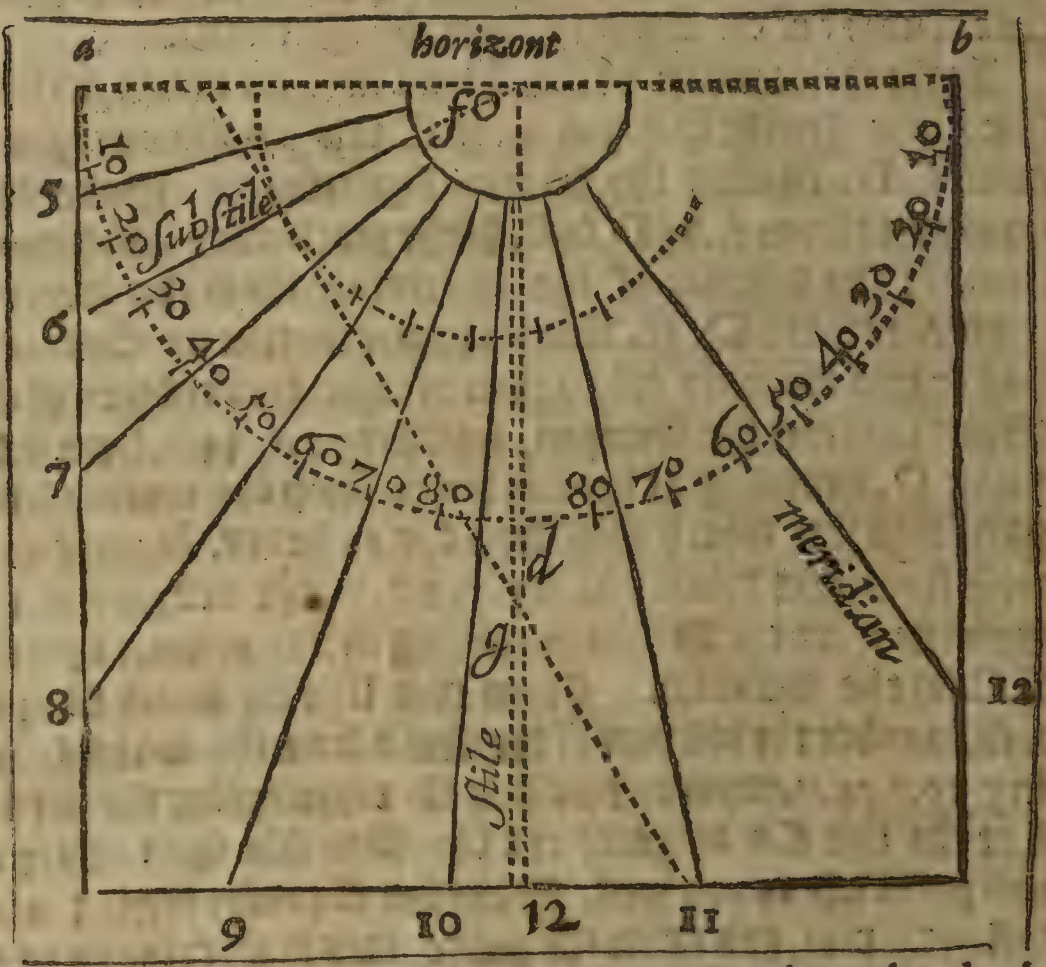
5 The diſtance of the Stile from the Subſtile 59.^{d}.54.^{m}.

6 Laſt the diſtance of the Subſtile from the Meridian 84.^{d}.33.^{m}.

But here (as before is taught) you muſt ſubtract this diſtance from 180.^{d}. becauſe the doubtfull Arke was leſſe than 90.^{d}. and then the remainder 95.^{d}. 27.^{m}. ſhall be the true diſtance of the Subſtile from the Meridian.

In the delineation of this Diall firſt, as before, make a line parallel to the Horizon A. B. Draw another perpendicular C.D. cutting the former ſquirewiſe. Make two quadrants from A. by D. to B. If the plat decline Weſtward, number the diſtance of the Meridian from the Horizon from A. toward D. &c. But if the declination be Eaſtward (as in this example it is) then account this diſtance of the Meridian from the Horizon, which is 54.^{d}. 44.^{m}. from B. toward D. drawing at the end thereof from the centre C. the Meridian line, which ſhall ſhew the 12 houre. Account likewiſe from that toward A. 95.^{d}.27.^{m}. the diſtance of the Subſtile from the Meridian: making in like manner the line E.C. for the Subſtile. From this line on which ſide you will, number the diſtance of the Stile from the Subſtile, being 59.^{d}.54.^{m}. draw by this line G. repreſenting the Stile. Let the line Contingence cut the Subſtile ſquire-wiſe in any point where you will. Make the Equator begin the diviſion thereof, and draw the houre lines in all reſpects as in the North reclining 21.^{d}. 5.^{m}. declining 30.^{d}. Chap. 15.

A South declining inclining Diall.



The ſecond example of a South Diall. { Inclining 33.^{d}.4.^{m}. Declining 31.^{d}. } Where the doubtfull Arke is ſubtracted from 180.

Firſt, 51503 the Signe of the Declination being multiplied, by 83227 the Sign of the Complement of the inclination; and the product 4286440181. divided by the whole Sign: the Ark of the quotient is 25^{d}. 23.^{m}. The Complement whereof being 64.^{d}.37.^{m}. is the complement repeated.

Then I increaſe the Sign of the Complement of the declination, which is 85716, by the whole Sign, and I part the product 8571600000, by 90346. The Sign of the Complement repeated. The quotient 94875 yeilding an Arke, 71.^{d}.35.^{m} which is the diſtance of the Meridian from the Horizon.

Again, I multiply this Sign 94875. by the Sign of the Complement of the inclination being 83227, and the product 7895961425 ariſing thereof, I divide by the whole Sign. The Ark of the quotient is 52.^{d}.9.^{m}, which is the Elevation of the Meridian.

Now this being added to the Elevation of the pole 52.^{d} and the to all number 104 ^{d}.9^{m}. taken from 180 there remaineth 75.^{d}.51.^{m}. which is the doubtfull Ark.

Therefore I augment 90346 the Sign of the Complement repeated, by 96930 the Sign of the dubtfull ark and the product 8760399890 I part by the whole Sign. The Ark of the quotient 61.^{d}.10.^{m}. is the diſtance of the Subſtile from the ſtile.

This done, I compare, 28.^{d}.50.^{m}. the Complement of this diſtance, with 14.^{d}.9.^{m}. the Complement of the doubtfull arke, multiplying the ſign of the leſſer, which is 24446 by the whole Sign, dividing the product 24446000007, by 48226 the Sign of the greater. The quotient ſign 50741 yeeldeth an ark 30.^{d}.30.^{m}. whoſe Complement 59.^{d}.30.^{m}. is the diſtance of the Subſtile from the Meridian.

The delineation of the figure

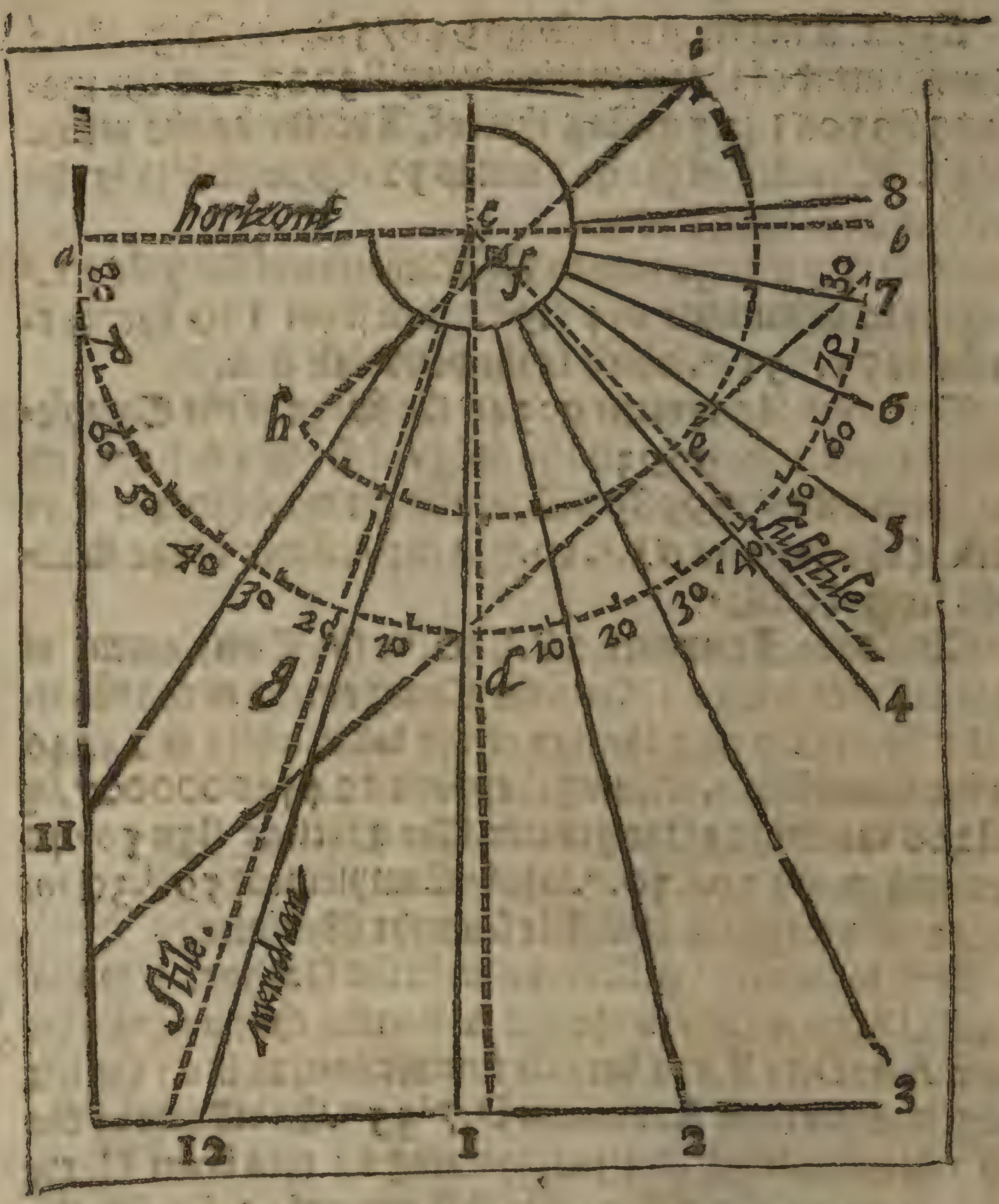
First, draw a line A.B. Parallel to the Horizon: draw another C.D. ſquire-wiſe to the line A.B. make the two quadrāts from A. by D. to B. and becauſe this declination is on the left hand, number from A. towards D. 7^{d}35^{m}. the diſtance of the Meridian from the Horizon, drawing by this from C. the Meridian line. From that toward B. account 59.^{d}.30.^{m}. the diſtance of the Subſtile from the Meridian, making in like manner at the end of the numbe from C. the Subſtile line E Againe from this forward (if you can, or elſe backward) number the diſtance of the ſtile from the Subſtile, which is 61, ^{d}.10.^{m}. draw likewiſe by this from C. the line G, for the ſtile Let the contingent cut the ſubſtile ſquire-wiſe in any place, where you will, &c. The making of the reclining declining Dials before, ſhall teach you the finiſhing of this likewiſe.

This [illegible]

outh

South

A South declining inclining.



and

The making of a North inclining declining Diall.

CHAP. 20.

The working of this kinde is altogether like the South reclining declining Diall.

Firſt, therefore multiply the Sine of the Declination, by the Sine of ẏ Complement of the Inclination dividing the product by the whole Sine. The quotient ſhall give an Arke whoſe Complement plemmẽt ſhall be named the Complement repeated.

Then augment the Sine of the Complement of the declination by the whole Sine, and the product part by the Sine of the Complement repeated. Whereof will come a quotient Sine; whoſe arke ſhall be the diſtance of that which is at it were the meridian from the horizon.

For the finding of the elevation of the Meridian, becauſe it may be done two ſundry wayes, I will ſet them down both, referring the choyce to your ſe ſe.

Compare the Complement of the Ark laſt found out, with the Declination of the plat, multiplying the Sine of the leſſer, by the whole Sine: and dividing the product by the Sine of the greater. The quotiẽt Sine ſhal yeeld an Arke whoſe Complement ſhall be the Elevation of the Meridian.

Or multiply the Sine of the arke laſt found out by the Sine of the Complement of the declination, part the product by the whole Sine: and the Arke of the quotient Sine ſhall be the elevation of the Meridian.

Now comparing the Elevation of the Pole with the Elevation the Meridian, ſubtract the leſſer from the greater, retaining the number remaining, which ſhall be called the difference kept.

Afterward increaſe the Sine of the difference kept, by the Sine of the Complement repeated, and divide the product by the whole Sine. The quotient ariſing of this diviſion ſhall give an arke, which ſhall be the diſtance betweene the Stile and the Subſtile.

To conclude, the Complement of this diſtance being compared with the Complement of the difference kept, multiply the Sine of the leſſer by the whole Sine, and part the product by the Sine of the greater. The Complement of the Arke of the quotient Sine, ſhall be the diſtance of the Subſtile from the Meridian.

But note, if the Elevation of the Meridian, and the Elevation of the Pole be found equall, make an Equinoctiall

Diall, as before you were taught in the Meridionall reclining declining: for there is no difference, but onely that this is placed downeward, and the South upward.

There be of this North, as of the South reclining declining, three ſundry kinds of Dialls, as by the examples and figures following you may perceive.

Firſt Example.

Example of a North Diall { Inclining 20.^{d}. / Declining 30.^{d}.

Firſt I multiply 50000 the Sign of the Declination by 93969 the Sign of the Complement of the inclination and the product thereof 4698450000 I divide by the whole Sign 100000, and the quotient Sign 46984 yeeldeth an Ark 28.^{d}.2.^{m}. whoſe Complement 61.^{d}.58.^{m}. is the Complement repeated.

Then I augment the Sign of the Complement of the declination, which is 86602 by the whole Sign, parting the product 8660200000, by 88267 the Sine of the Complement repeated; the quotient is 98113. The Ark thereof being 78.^{d}.51.^{m}. is yͤ diſtance of yͤ Meridian from yͤ Horizon.

Two waies in working the example, for the two precepts of the finding out the Elevation of the Meridian.

Now in comparing the Complement of the Arke laſt found out, with the declination of the plat: I find the Complement of the ark leaſt. Wherefore I multiply yͤ Sine thereof being 19337 by the whole Sine and the product 1933700000, I divide by 50000 the Sine of the greater. The quotient 38673 giveth an ark 22.^{d}.46.^{m}. whoſe Complement 67.^{d}.14.^{m}. is the Elevation of the Meridian,

Both theſe tend to one end.

Or multiply 98112 the Sine of the ark laſt found out, by the Sine of the Complement of the Inclination, which is 93969: and the product 9219596568 part by the whole Sine. The quotient ſhall bee 92192, whoſe Ark 67 degrees 14 minutes is the Elevation of the Meridian.

This done, I compare the Elevation of the Meridian 67.^{d}.14.^{m}. with the Elevation of the Pole 52.^{d}. ſubſtracting yͤ leſſer from the greater, and there remaineth 15.^{d}.14.^{m}. which is the difference kept.

Then I multiply 26275 the Sine of the difference kept by 88267 the Sine of the Complement repeated: parting the product 2318455682, by the whole Sine. The Arke 11.^{d}.47.^{m}. of the quotient Sign 23184, is the diſtance of the Stile from the Subſtile.

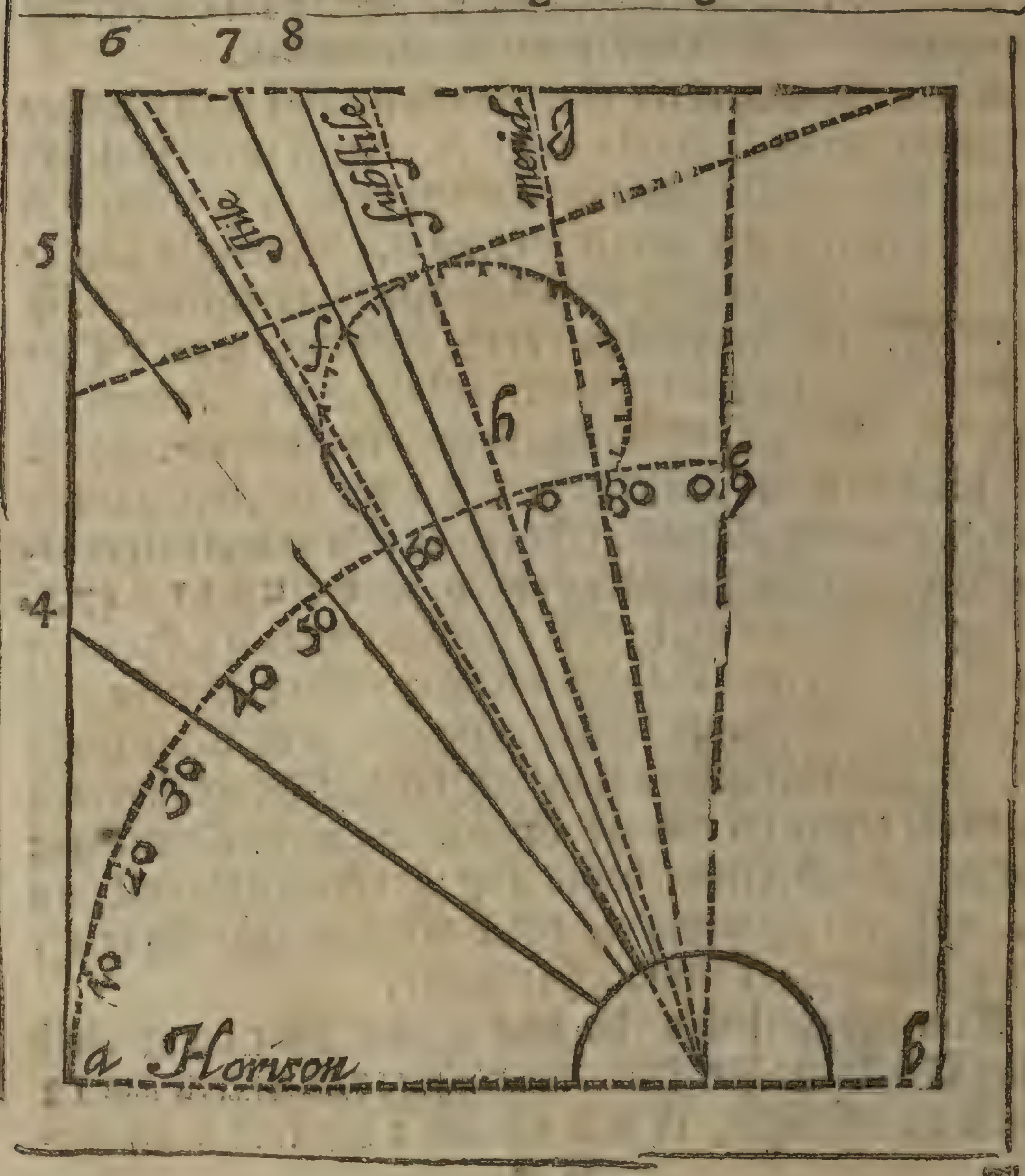
Now the Complement of this diſtance being 76.^{d}.36.^{m}. compared with 74.^{d}.47.^{m}. the Complement of the difference kept, I increaſe 96494 the Sign of the leſſer, by yͤ whole Sign and yͤ product thereof 9649400000, I diſtribute by 97277 the Sign of the greater. And the quotient is 99191, whoſe Ark is 82.^{d}.43.^{m}. The Compleme͂t whereof being 7.^{d}.17.^{m}. is the diſtance of the Subſtile from the Meridian.

The delineation of the Diall.

If the Equator of the Meridian be greater then the Elevation of the Pole, draw a line A.B. parallel to the Horizon make another C.D. ſquirewiſe to the former, deſcribe the quadrant on the left hand from A. to C. (becauſe the Declination is on the right hand (numbring therein from. A. upward 76.^{d}.32.^{m}. the diſtance of the Meridian from the horizon, draw at the end thereof from D. the line C. repreſenting the Meridian. From this backward toward A. account the diſtance of the Subſtile from yͤ Meridian, which is 7.^{d}.41.^{m}. making likewiſe at the end of this number from D. the line E. for the Subſtile. From hence account 11.^{d}.47.^{m}. being the diſtance of the Stile from the Subſtile, drawing in like manner from D. the line F. for the Stile. Let the line of Contingence out the Subſtile ſquirewiſe as before make the Equator in this, as in the other before. Place the ruler upon the centre H. and the interſection of the Contingent line, and the Meridian, beginning the diviſion thereof into 24 equall parts, where the ruler ſhall touch the Equator. Finiſh all things remaining as before.

Remember that in this kind of North inclining declining Diall, the Meridian line rather repreſenteth the 12 houre at midnight, than in the day: whereof in accounting the houre lines, let the Meridian be alwayes for the 12 houre in the night. And then if your plat decline Weſtward account backward as it were 11. 10. 9. which houres wit the 12 you may omit in the delineation of your Diall. becauſe they have no uſe in our Elevation. But account forward 8. 7. 6 5. 4. &c. ſo many as you think ſhall be neceſſary for ſome declination will receive more, than other will: the greater the more, the leſſer the fewer houres. But if the declination of the plat be Eaſtward, then account from the Meridian line forward 1. 2. 3. 4. &c. ſo many as ſhall be needfull, omitting likewiſe yͤ firſt three, &c.

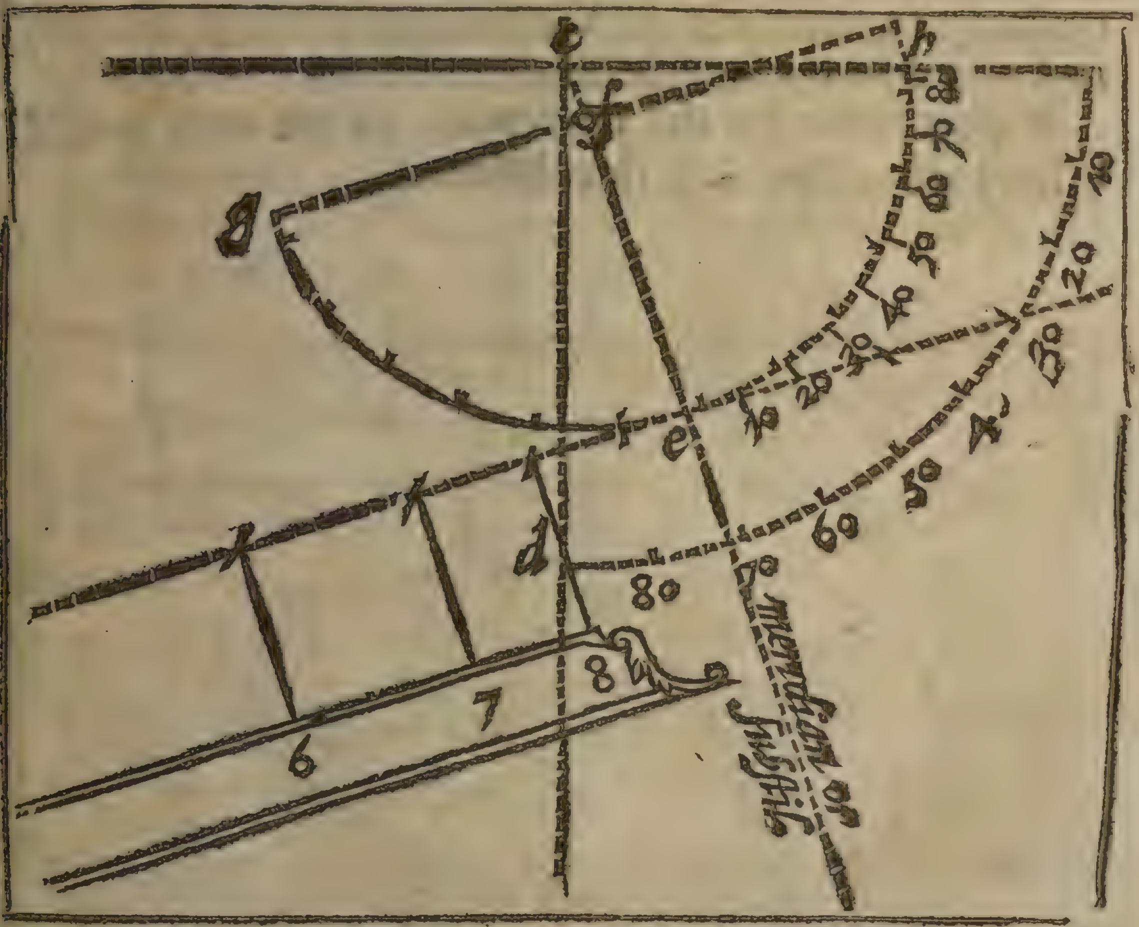
A North inclining declining.



The ſecond kinde.

But if the Elevation of the Meridian, and the Elevation of the Pole be equall, the making of the Diall differeth from the other before. For an example hereof, and the drawing of the Figure, reſort to the South reclining 33.^{d}.30.^{m} declining 32.^{d}. for theſe are both alike, onely remember here that if this decline Eaſtward, make the quadrant likewiſe on the Eaſt ſide, &c. But if the plat decline toward the Weſt, make the quadrant Weſtward (as in the Figure following) finiſhing all things elſe as here you ſee done. Obſerve the ſame order in naming the houre lines which I taught you before.

A North inclining declining.



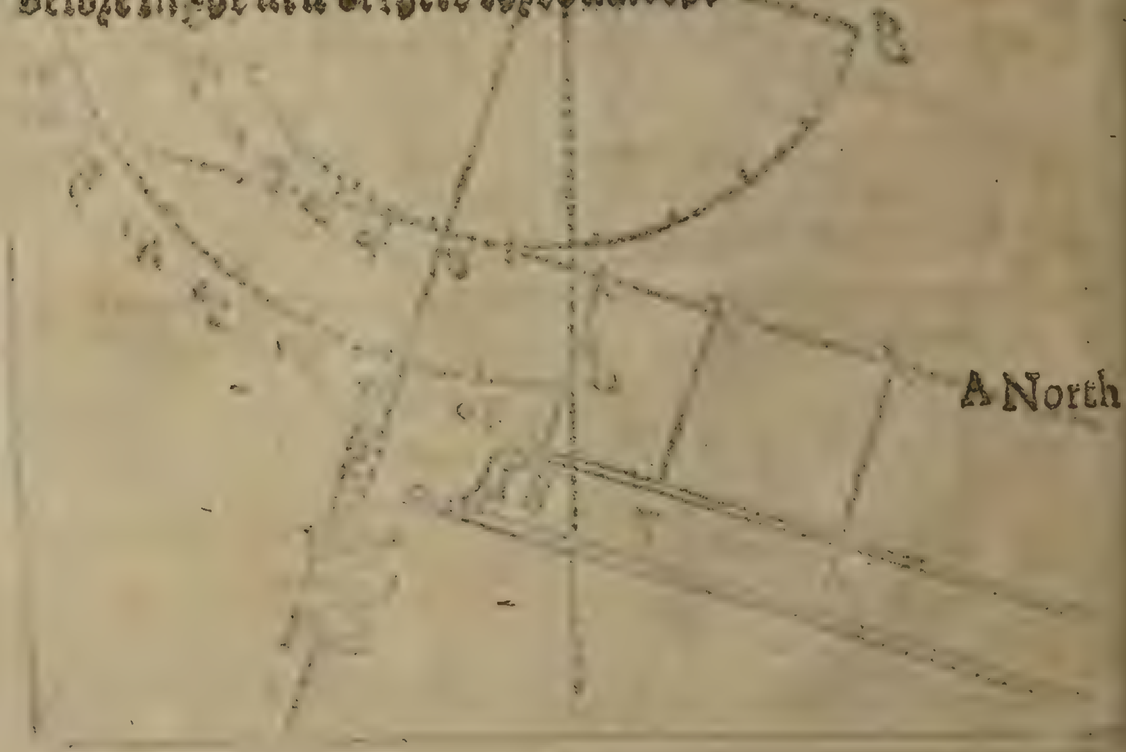
The third Example of a North Diall. { Inclining 45.^{d}. Declining 45.^{d}.

If the Elevation of the Meridian be leſſer than the Elevation of the Pole, make your Diall thus.

For the working of the example, and the delineation of ẏ Figure, reſort to the South reclining 45.^{d}. declining 45^{d} for that agreeth with this, except onely that in this, the Stile is placed downward, and ſheweth but few houres, and thoſe likewiſe are drawn downward: but in the other the Stile ſtandeth upward, ſhewing many houres, and thoſe likewiſe for the moſt part are drawn upward. Mark alſo in this kinde, if your plat decline Weſtward, draw the quadrant on the Weſt ſide, but, if the Declination be Eaſtward, make the quadrant on the Eaſtſide, &c.

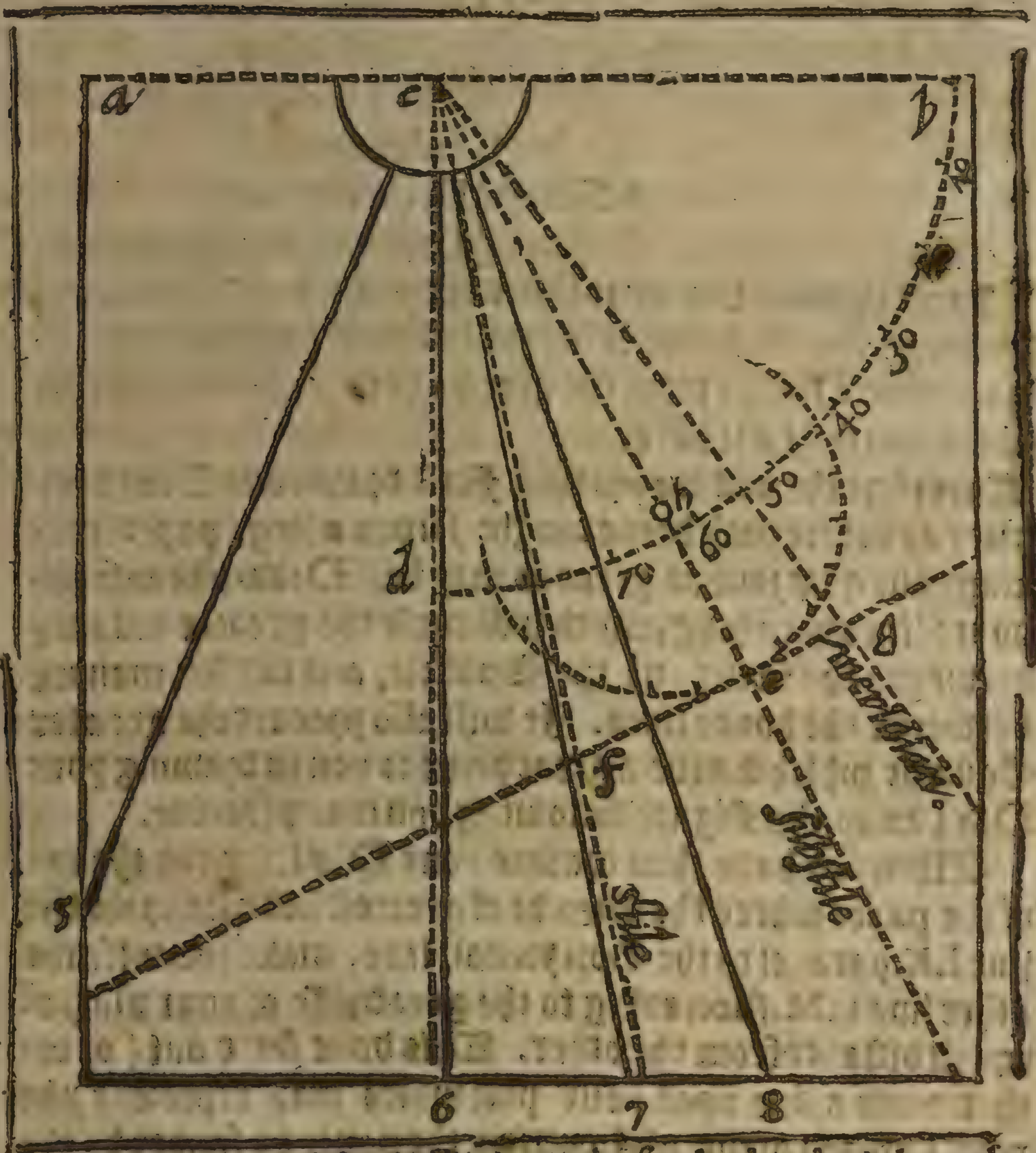
The making of theſe, are more pleaſant to know, than profitable to uſe: unleſſe the Declination be the greater, for ſo it may ſhew the more houres.

For the naming of the houres, doe as you were taught before in the firſt of theſe three kindes.



A North

A North Declining Inclining.



The delineation of thoſe Dials, whoſe plat lyeth nigh to the Elevation of the Pole.

CHAP. 21.

WHereas the declination and reclination, or declination, and inclination, ſhall cauſe the plat of your Diall to lie nigh to the Elevation of the Pole, then the houre lines muſt be drawne very lõg, to make the diſtances ſõewhat large, ſo that they may be diſcerned one from another. And commonly theſe following be ſuch as here we meane.

A South Reclining direct.
Declining erect.
Declining reclining.

An Eaſt or Weſt Reclining.
Inclining.

A North Inclining direct.
Declining erect.
Declining inclining

In all theſe kindes oftentimes the diſtance betweene the Stile and the Subtile is ſo ſmall, that it is not poſſible to draw your Diall, except the plat be very large: which at all times you ſhall not have.

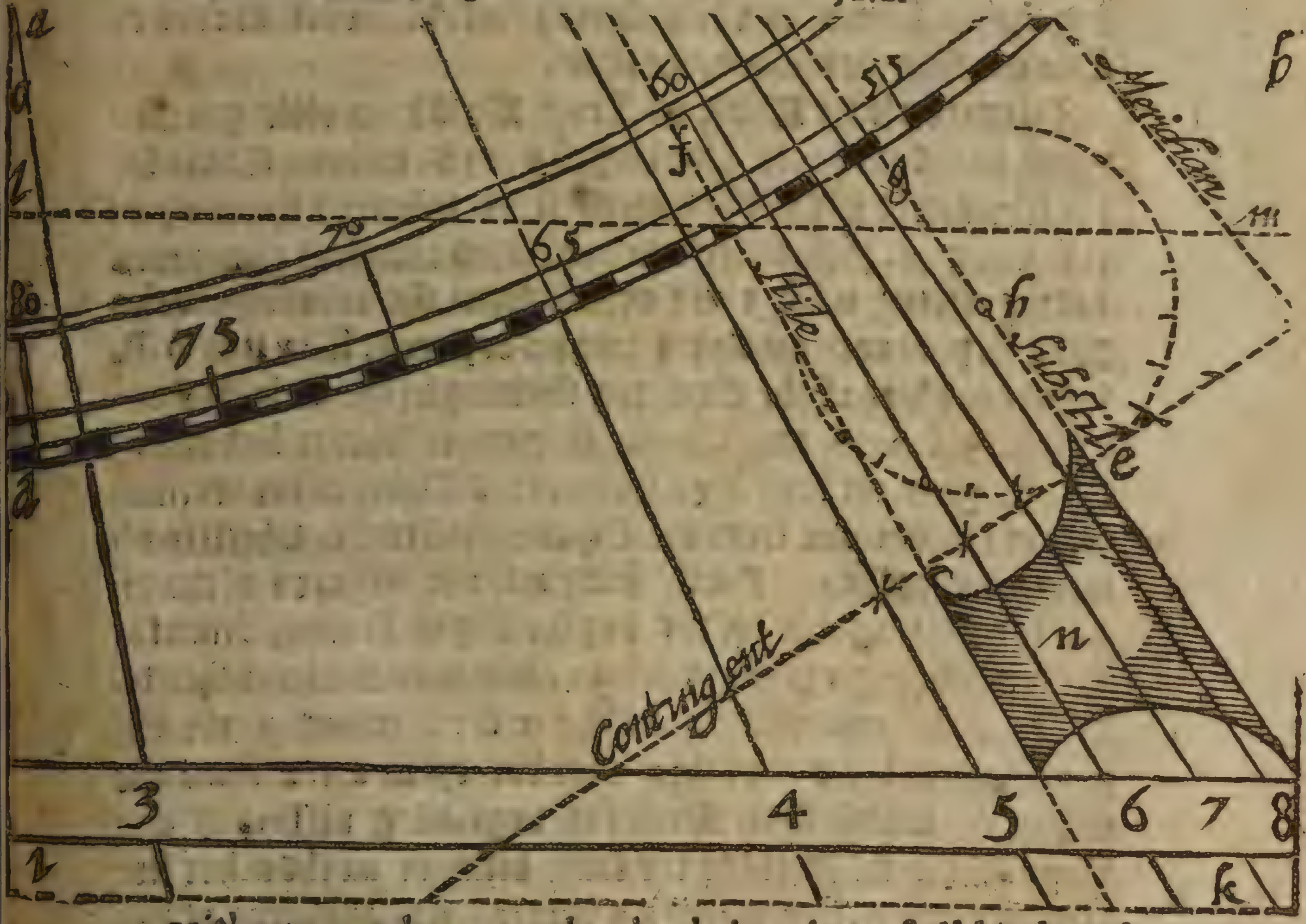
Therefore the beſt way is this. Firſt draw your Diall very true (as before hath beene taught) upon a large paper, making your quadrant as great as may be. Draw likewiſe the houre lines very long, which will cauſe the greater diſtance betweene the Stile and the Subſtile, and in like manner betweene the houre lines. It will alſo procure the greater Equator, which ſhall be a great helpe to you in drawing your Diall as by the Figure following you may perceive.

When you have thus drawne your Diall, then at the end of the paper where the lines be of greateſt diſtance, draw the line I.K. parallel to the Horizontall line, make likewiſe the other line L.M. (according to the greatneſſe of your plat) of equall diſtance from the other. This done, finde out (or rather draw a line upon your plat which may repreſent) the true Horizon of the plat: cutting the paper in ſunder by the line I K. and the line L. M. placing it upon your plat very plain ſo that one of the edges may be parallel to the Horizon Then make markes upon the plat at both ends of all the houre lines, drawing by thoſe markes, the lines for the houres. Draw likewiſe light lines upon the plat for the Stile and the Subſtile, eaſily to be diſtinguiſhed as you did upon the paper.

Let the ſtile N. be faſtened over the Subſtile, as you have beene taught in the Eaſt, and Weſt, or Equinoctiall Dials. But here note, that the Stile muſt not be of equall height at both ends. But let it be ſo high, as the diſtance betweene the Stile and the Subſtile is in the place where it ſtandeth, as in the examples following you may plainely perceive.

A North Diall.

Declining Weſtward ——— 65 d.
Inclining ——— 22.d.20.m.
Diſtance of the Meridian from the Horizon - 50.d.50.m
Diſtance of the Subſtile and the Meridian ——— 6.d.35.m.
Diſtance of the Stile and Subſtile ——— 4.d.15.m.
Elevation of the Pole ——— 52.d.



Hitherto we have taught the delineation of all kindes of Dialls, which are to be made upon any plaine plat or ſuperficies now followeth the garniſhing of them, with the 12 Signes and the houres unequall.

The Art of Dialling.

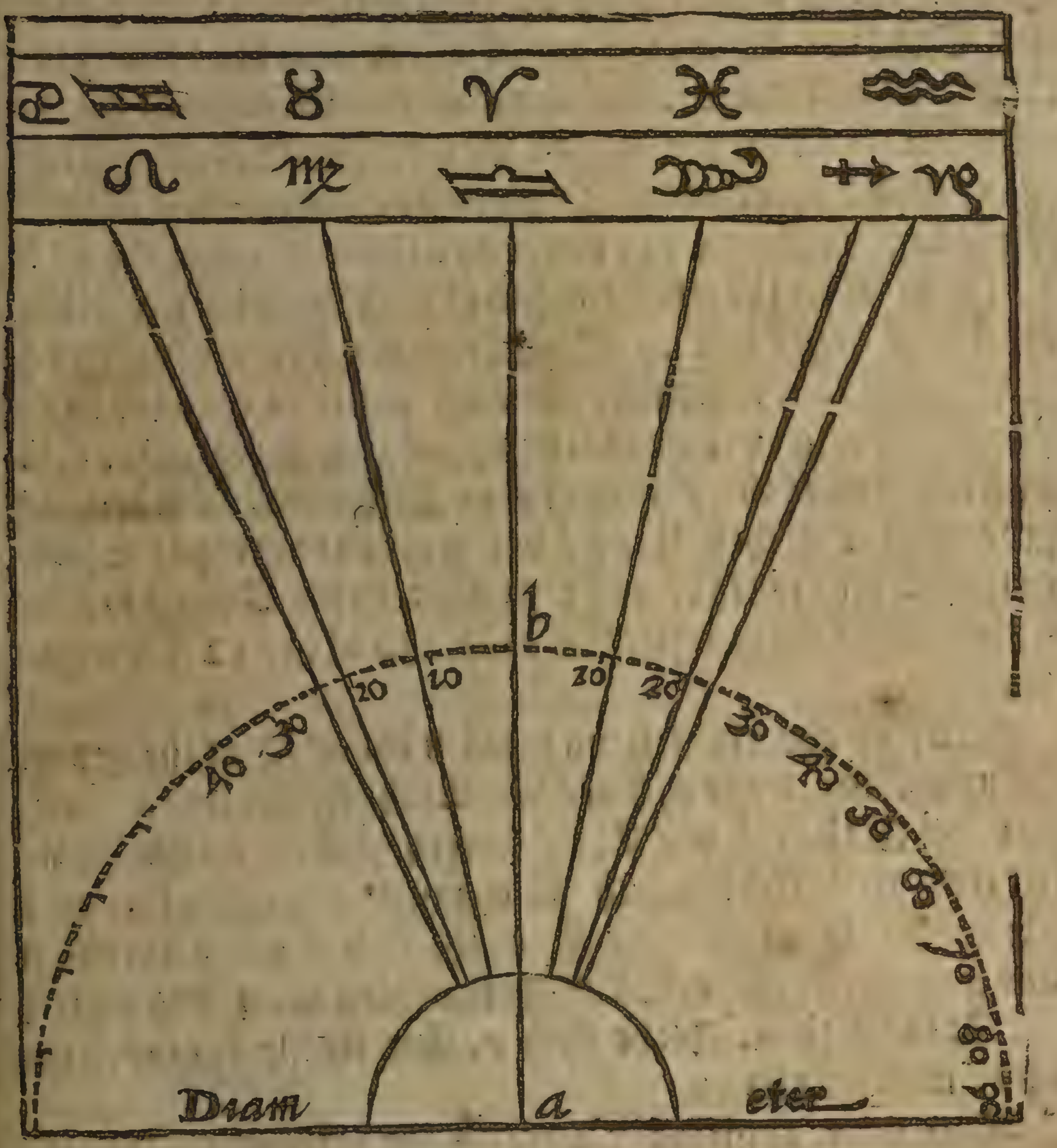
How to draw the 12. Signes in all kind of Dials before mentioned.

CHAP. 22.

FOrſomuch as ſometime the 12. Signes of the Zodiake are placed in Sunne Dials, to know in what ſign the Sunne is at any time (which albeit any kinde will receive, yet moſt commonly the verticall directly oppoſite to the South are garniſhed therewith:) Therefore in drawing the 12. ſignes, in theſe South, and all other kindes of Dials before mentioned, doe thus.

Prepare a little Table of Iron, Braſſe, or cloſe grained wood, in breadth 3. or 4. in length 5. or 6. inches. Chuſe for the Diameter one of the ſhorteſt ſides, wherein draw upon the centre *A.* halfe a circle to be divided into two quadrants diſtinguiſhing with a line drawn from the centre A. to the Arke B. part each quadrant into 90 degrees. The line A.B. is here in place of the Equator, ſhewing in the Arke the beginning of Aries and Libra. Moreover how to finde the other Signes on both ſides, ſeeke in the Table of the declination of the Sunne from the Equinoctiall circle, which is afterward expreſſed. Firſt, finde out the degrees of the diſtance (in this table) of the beginning of Taurus, from the Equator, being 11. degrees, 30. minutes. Account this diſtance in the quadrant from the letter B. towards the left hand and at the end of this number draw a line from the centre A. which ſhall ſhew the beginning of Taurus and Virgo. Account likewiſe the ſame diſtance on the other ſide from the line A.B. and make a line for the beginning of Piſces and Scorpius. Againe in the $20.^{d}$ $12.^{m}$ from the line A.B. you ſhall have the beginning of Gemini and Leo: and ſo many degrees and minutes on the other ſide, the beginning of Aquarius and Sagittarius. To conclude on both ſides in the 23. degrees 30. minutes, there muſt be on the one part Cancer and on the other Capricorne.

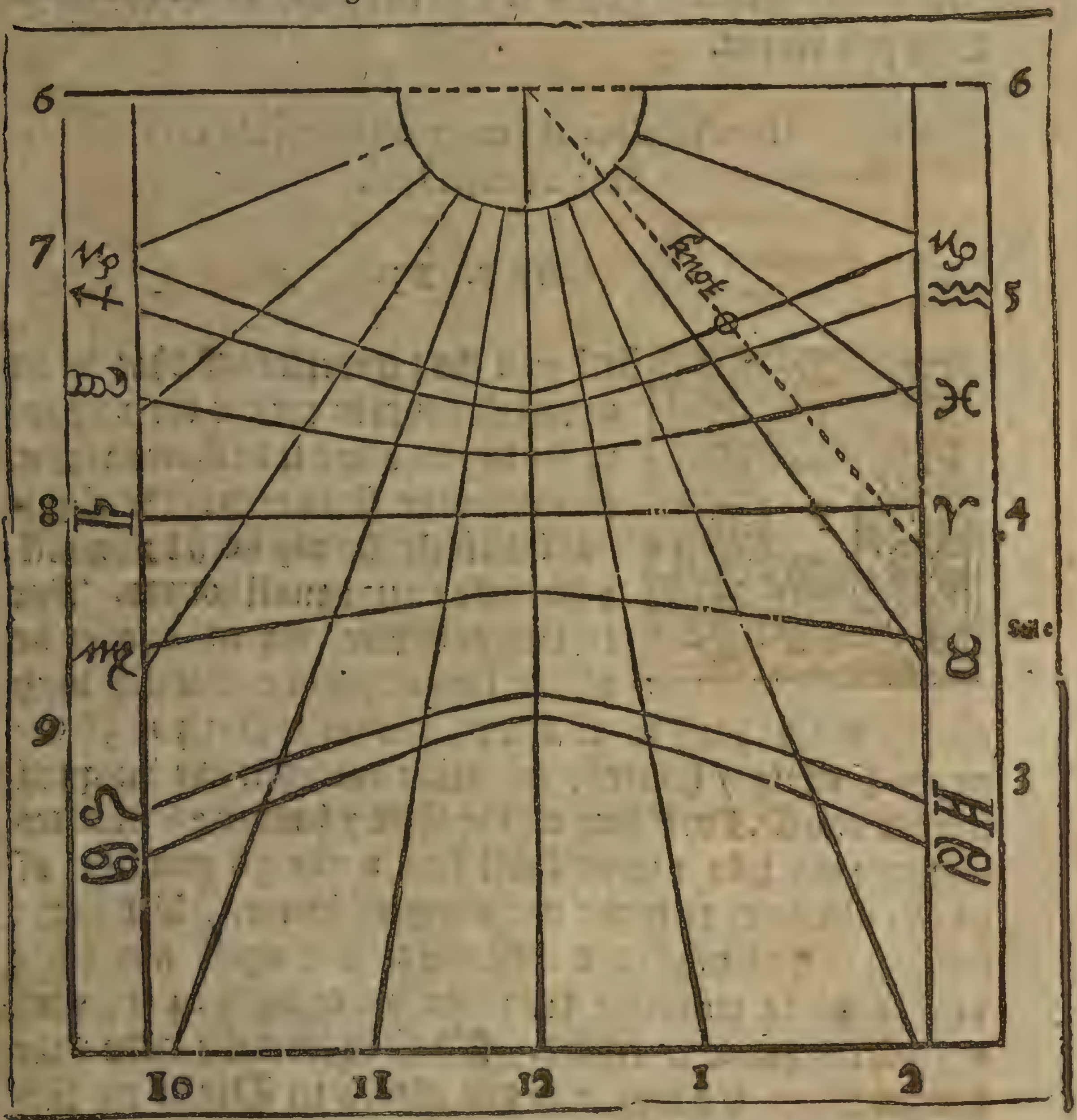
Afterward draw lines from the centre A. by every marke ſo long as your Table will receive: and at the end of theſe lines let the caracters of the 12. ſignes of the Zodiake bee fixed: as in the figure following you may ſee.



YOur Diall being made, and the Stile placed therein: take your Trigonall Inſtrument, and ſet it upon the Stile, ſo that the whole Diameter thereof may ſtand plaine upon the edge or upper part, the centre A. of your Inſtrument alwayes remaining in one place of the Stile. Let the line ♋ bend upward to the centre of your Diall, and the line of ♑ downeward. Then faſten a thread at the uppermoſt end of your Trigonall in every line of the ſignes, ſo ÿ you may direct downeward by the centre A. to the plat of your Diall: and where the end of the thread ſhall touch the Diall, make a marke. Then moving the Trigonall on the right hand, ſo that the thread may be ſtretched on the left hand, make there likewiſe a prick upon the plat. When you have thus done 4 or 5 times upõ the one ſide of the Diall: (that is on the left hand) doe ſo likewiſe on the other ſide on the right hand. Theſe markes being thus made, draw (with your compaſſes, or rather with a crooked ruler made according to thoſe markes) a line by them. Doe thus with each one of the 7 lines of your Trigonall. When you have drawne all theſe lines, (being crooked except the middle line, which is right, and repreſenteth the Equator) then at the ends of them write the caracters of the 12 ſignes on this wiſe.

Firſt, on the right hand toward the Eaſt at the end of the upper line, write or place ♑. At the ſecond line downeward ♒ At the third ♓ At the fourth ♈ At the fifth ♉. At the ſixth ♊. At the ſeventh ♋. Then on the other ſide of ÿ left hand toward the Weſt at the end of the nethermoſt line place ♋. At the ſecond ♌. At the third ♍. At the fourth ♎. At the fifth ♏. At the ſixth ♐. And finally againe at the uppermoſt part ſet ♑.

This done, remember that in what place of the ſtile the centre A, of your Trigonall was placed, there faſten a ſmall piece of iron or any ſuch like thing, which may ſhew with yͤ ſhaddow thereof, the Signe which the Sunne ſhall be in at any time: unleſſe the houre lines be ſo ſhort, that where the ſmall peice of Iron ſhould be placed, you may cut the Stile that the end thereof ſhall ſhew it. But the firſt is the moſt convenient way for the uſe thereof.



You may in like manner with this Inſtrument draw or place the 12 ſignes in Horizontall, Eaſt, Weſt, and all other kindes of Dials, which before are recited: becauſe the difference

John

difference is nothing but in placing the 12 ſignes at the ends of the lines: the true doing whereof, you may eaſily perceive by the courſe of the Sunne. For in the South Erect, when the Sunne occupieth Cancer, then is the line of ♋ furtheſt diſtance from the centre of the Diall. But in the Horizontall Diall, the line of ♋ is next to the centre. Few words ſhall ſuffice for this matter: experience ſhall eaſily teach you herein.

How to place the unequall houres in a Horizontall Diall.

Chap. 23.

First you ſhall underſtand, that by an unequall houre is meant the 12 part of the day whether it be ſhort or long. For when the Sunne is in the Equinoctiall circle the day hath 12 equall, & likewiſe 12 unequall houres. But in winter ſolſtice, when the dayes be at the ſhorteſt, and containeth with us (where the Pole is Elevated above the Horizon 58 degrees) onely 7 houres, 30 minutes: then the unequall houres be leſſe. For if you divide theſe 7 houres 36 minutes by fractions into 12: you ſhall find onely 38 minutes of an equall houre, to make one unequall houre. But in the ſummer ſolſtice, when the dayes be at the longeſt, and hath 16. houres 24 minutes: then one houre with 24 minutes maketh one houre unequall. Theſe be likewiſe called the houres of the planets, and are placed in Dialls on this manner.

Your Diall being made and prepared, draw upon it the 12 ſignes of the Zodiake (as you were taught before) ſo large as your plat will give you leave, &c.

Note that alwayes the Meridian line, or 12 equall houre is the 6 vnequall houre. Marke likewiſe, that when the Sunne entreth into the beginning of ♈ and ♎, both the equall and unequall houres be of like quantity. For the 7 equall houre in the morning is the firſt unequall, and the 8 equall the ſecond planetary houre, &c.

But in the Tropike of ♋ it is otherwiſe: for then the unequall houres be greater then the equall. Therefore account how many houres and minutes is in the longeſt day for your Elevation, changing all the minutes of thoſe houres into one totall ſumme. Then divide this number by 12: and the quotient ſhall ſhew how many minutes of an equall maketh one unequall houre. Example hereof: with us the longeſt day is 16 houres 24 minutes. Wherefore I multiply 60 which is the minutes of an equall houre, by 16 which is the ſumme of houres of the longeſt day, and the product ariſeth to 960, whereunto I adde 24 minutes remaining, then the number ſhall be 984, which being divided by 12 the quotient is 82. Wherefore I conclude that 82.^{m}. of an equall, maketh one unequall or planetare houre. Then to draw them in Dialls, worke thus.

Firſt, in the Tropike of ♋ divide the ſpace betweene each houre into 60 equall parts, but becauſe thoſe diſtances bee ſo ſmall for the moſt part, that this cannot be done: therefore it ſhall ſuffice to divide every one of them into three equall parts. Then ſhall every part containe 20.^{m}. and three of them 60.^{m}. which is one equall houre.

When as therefore you will place the 7 unequall houre, account from the Meridian line, or the houre, 4 parts and 2 minutes (which is 82 minutes) and make there a marke. Then place your ruler by this point or marke, and the interſection of the line of ♈ and ♎, and the firſt hour after noone: draw a line from one Tropike to another, that is from ♋ to ♑.

Then for the placing of the 8 vnequall houre, account from the 7 laſt marke, 4 of the foreſaid parts and two minutes; make there a marke, by which and the interſection of the line of ♈ and ♎ and the line of the ſecond houre afternoone, the ruler being placed, draw a line, as before.

For the 9 account from the 8 laſt made, likewiſe 4 parts and two minutes, drawing a line as before. Doe in like manner for the drawing of all the other remaining: that is, for the 10 and 11. The 12 being the Sunne ſetting, ſhall neede no line.

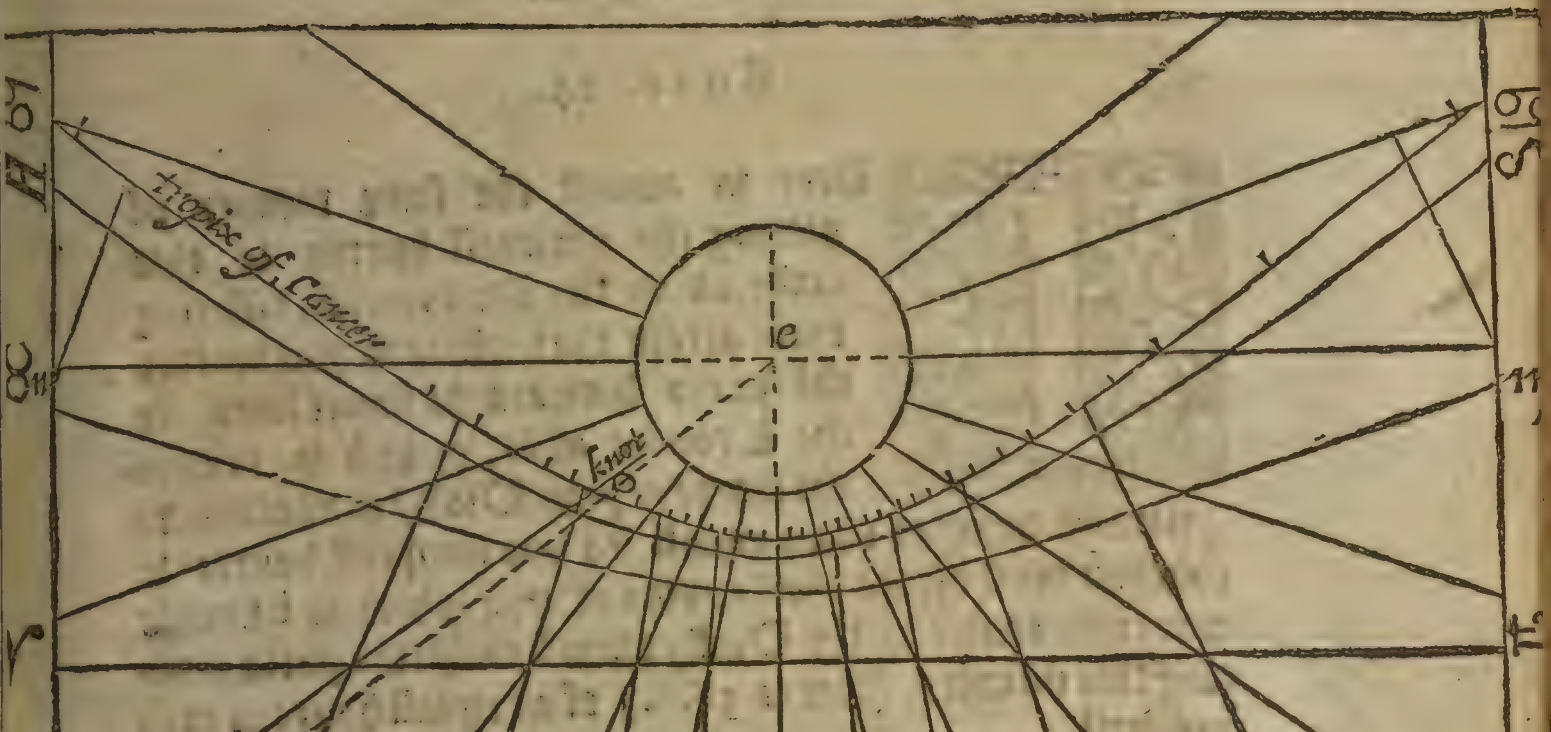
As you have finiſhed the unequall houres on this ſide for the afternoone, doe in like manner for thoſe in the forenoone: accounting from the Meridian 4 parts and 2.^{m}. of an equall houre, to each unequall, drawing, as before, lines from one Tropick to another.

You may place the figures for the unequall or planetary houres, at the end of the lines under the Tropike of Capricorne, or above the line of Cancer as you will,

Note that the ſame part of the Stile which he ſheweth the 12 ſignes, ſhall likewiſe ſhew the unequall houres. For better underſtanding hereof,

Behold the Figure following.

An Horizontall Diall,



How to place the houres unequall in a South erect direct Diall.

CHAP. 24.

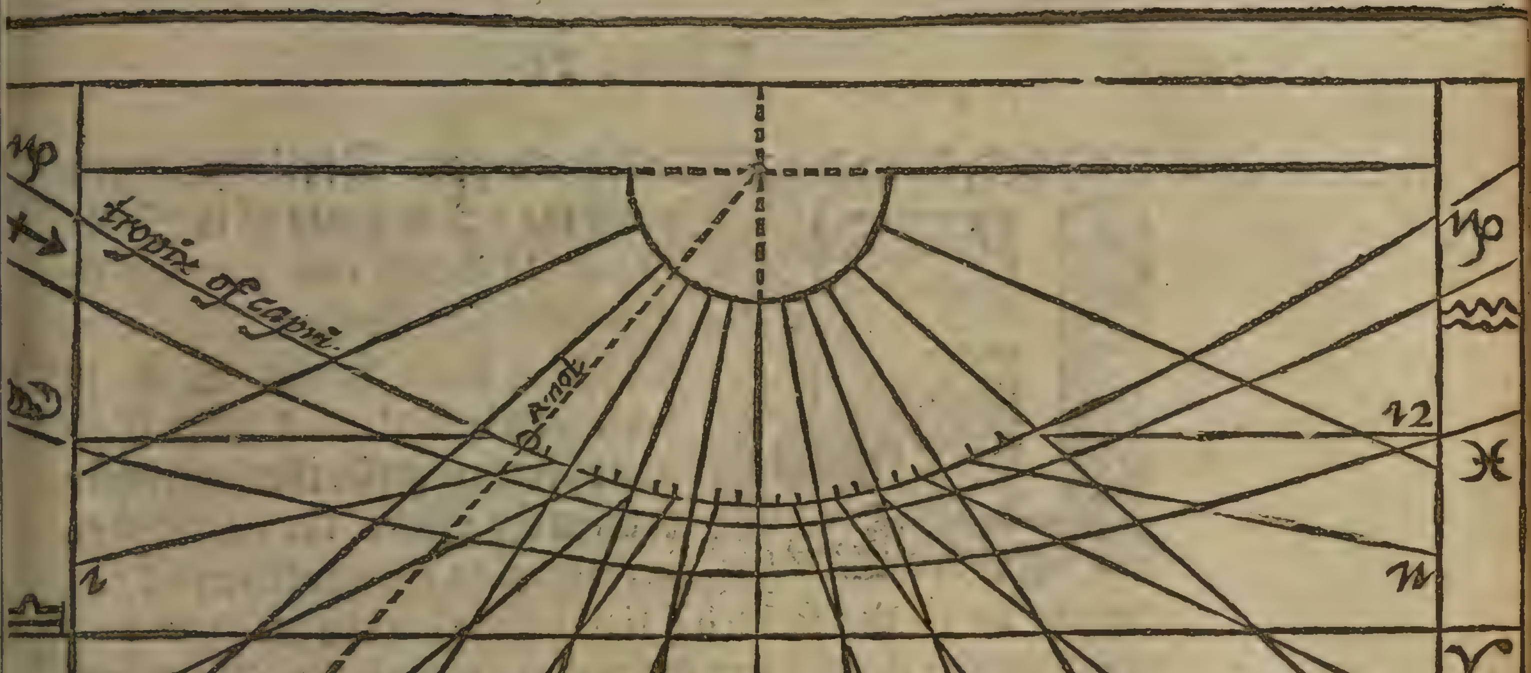
THere is almoſt the ſame manner of placing the unequall houres in this kinde, as in the Horizontall, differing onely herein that whereas you divided the ſpaces betweene the houre lines, in the Tropike of ♋, (which is next to the centre of your Diall) and accounted 4 parts 2 minutes of an equall to one unequall houre: in this you muſt divide the Tropike of ♑, (which is likewiſe next to the centre of the Diall) taking onely two parts wanting two minutes, (that is 38.^{m}.) of an equall houre to each unequall.

Therefore your Diall being prepared, and the 12 ſignes of the Zodiacke placed therein, &c. account how many houres and minutes bee in the ſhorteſt day in your Countrey, changing all the houres into minutes (giving to each houre 60. minutes.) Divide the product by 12, and the quotient ſhall ſhew how many minutes of an equall, will be anſwerable to each unequall houre. Example, the ſhorteſt day with us is 7 houres, 36 minutes, which being multiplied into one groſſe number of minutes, the product is 456, which I divide by 12, and the quotient is 38. Therefore I affirme that 38 minutes of a vulgar or equall, maketh one planetary or unequall houre

Then divide the Tropike of ♑ here, as in the Horizontall you did the Tropike of ♋. Afterward account from the Meridian line 38, m. (or 2 parts wanting 2, m.) of an equall houre to each unequall, &c.

Finiſh all things elſe in this Meridionall erect direct, as you were taught in the Horizontall. The Figure enſueth.

A South Diall.



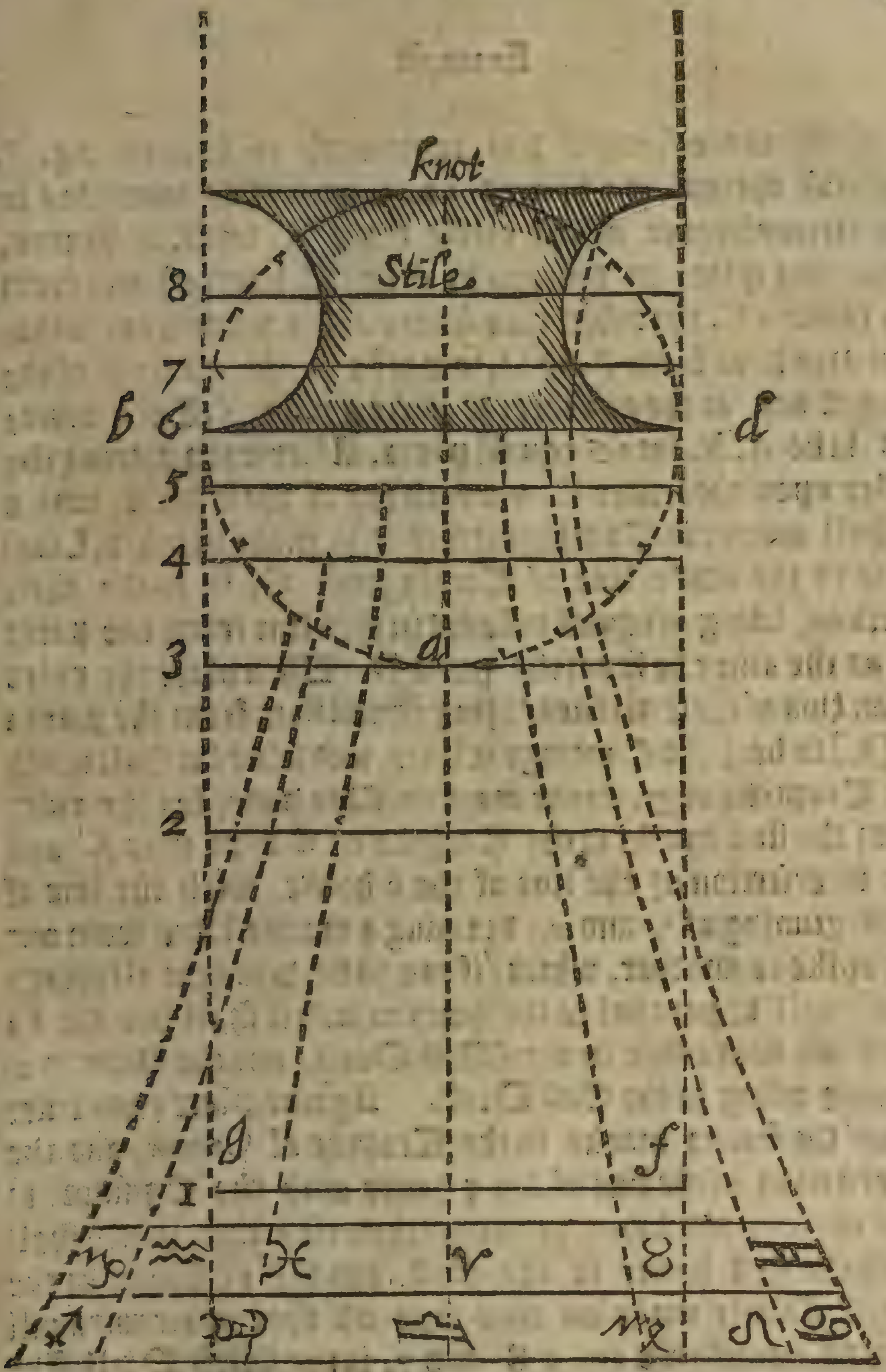
The

The placing of the houres unequall in eaſt and weſt Dials.

CHAP. 25.

FIrſt, draw your Diall true, then place the 12. Signes of the Zodiake in it: which you may doe in this wiſe. The Stile of your Diall being fixed therein, as before hath been taught, take your Trigonall (before preſcribed) and place it upon the edge of the Stile: then according to the direction of the thread (as in the South Diall before) make markes upon the plat as in the Figure following you may ſee. Afterward by theſe markes draw lines as before you did, placing at the ends of them the Characters of the 12 Signes.

Moreover note, that where the centre A. of your Trigonall doth touch the edge of the Stile, there faſten a ſmall piece of Iron or ſuch like thing, which may ſhew the place of the Sunne in every Signe, and likewiſe the planetary or vnequall houres.

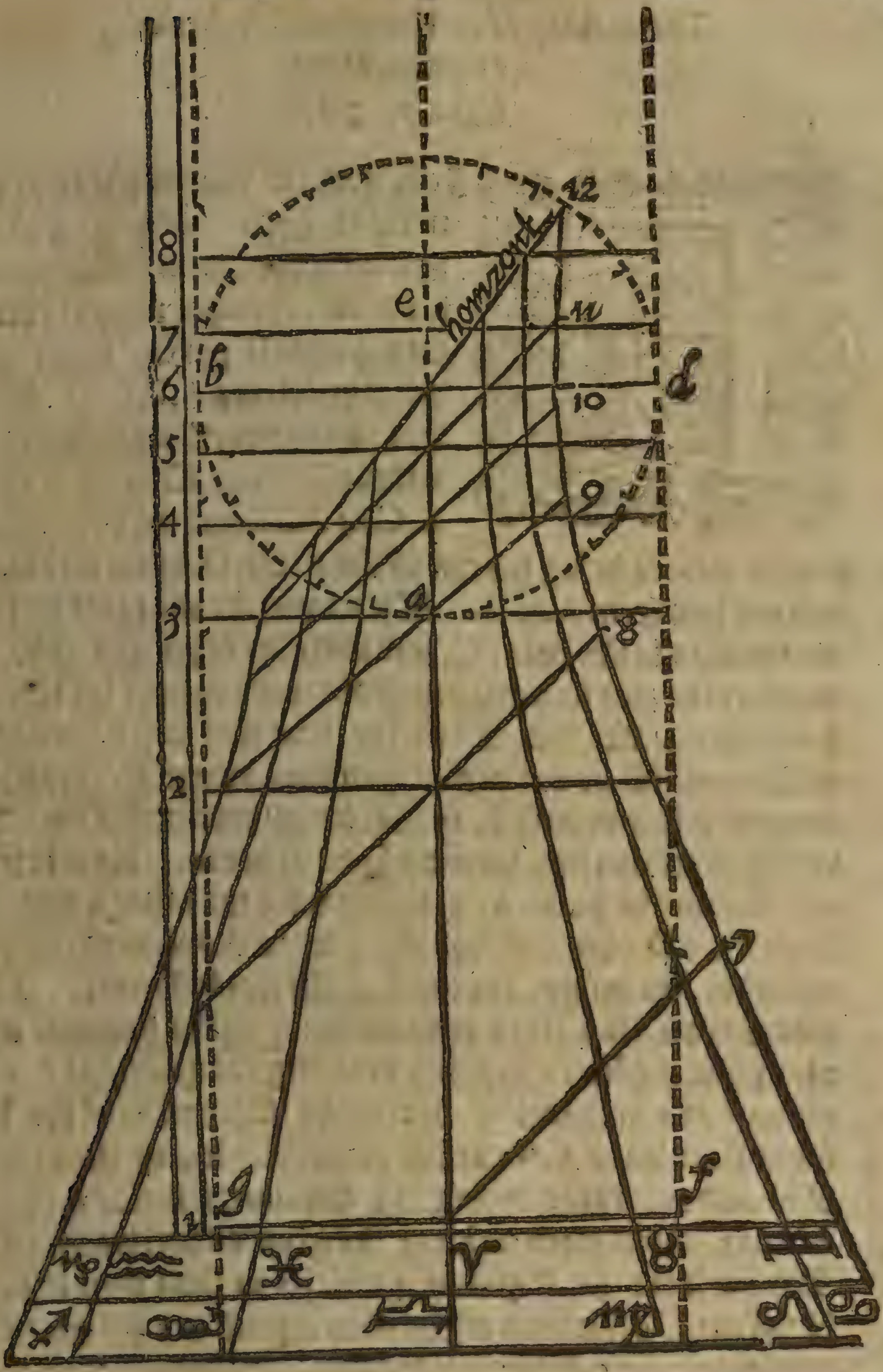


When as therefore you would place the houres unequall in thoſe kinds of Dialls, account the number of houres and minutes, which the halfe of the longeſt day in your Country doth containe.

Example

Example

With us the longeſt day containeth 16 houres, 24. m. the halfe thereof is 8 houres 12. m. wherefore numbring in the circumference of the circle from A. to D. 6 houres, (for that quadrant containeth 6 equall houres) and from D. toward C. the other two hours and 12 minutes, ſo that you may have from A. by D. towards C. the firſt halfe of the longeſt day at the end thereof make a point X. Then divide the Arke A. X. into 6 equall parts. Afterward placing the ruler upon the centre E. and each one of theſe parts where it ſhall touch the Contingent line D, F. make markes. Likewiſe in the other line of Contingence G. B make theſe markes, being of equall diſtance in this line from the point B. as the other be from the point D. Then place the ruler upon two of theſe markes (being equidiſtant from the points B.D.) in both the Contingent lines and where it ſhall touch the Tropicke of ♋, make markes. This done, lay the ruler upon the firſt marke in the Tropike of ♋ next unto X. and the interſection of the line of the 6 houre, with the line of the beginning of ♈ and ♎, drawing a manifeſt line from one Tropike to another, which (if you have wrought all things true) will be parallel to the horizon, and it ſhall bee the 12 unequall houre-line in the Weſt Diall, and the Horizon or Sunne riſing in the Eaſt Diall. Againe, place your ruler upon the ſecond marke in the Tropike of Cancer, and the interſection of the line of the 5 houre with the Equator, or line of Aries and Libra, drawing likewiſe a line, which ſhall ſhew the firſt houre in the Eaſt, and the 11 houre in the Weſt Diall: make on this wiſe all thee other unequall houres, namely the 10. 9 8 and 7, in the Weſt Diall. And the 2, 3. 4, 5, in the Eaſt Diall.


42
horizont
8
7
6
5
4
3
2
1
e
u
b
d
10
9
a
8
g
f
♑
♒
♓
♈
♉
♋
♐
♏
♎
♍
♌
♋

The making of an Horizontall Sphericall, or hollow Diall.

CHAP. 26.

FIrſt, prepare your Sphere or plat perfectly hollow, of what quãtity you will: then with your compaſſes divide the upper brim thereof, into 4 equall parts, making it with the letters A.B.C.D. Afterward upon your Compaſſes to the wideneſſe of one Quadrant, either A.C. or A.D. and with that wideneſſe one foote being places in the point D. draw an obſcure or light line from A. to B. This done, ſet one foote of your Compaſſes in the point C. and with the other you ſhall try whether the plat be perfectly Sphericall or not: for if it be, your Compaſſes will fall in the ſame line which you made before, but if it be not perfect, you may amend it. And then draw this line manifeſt, ſo that it may continue. For it ſhall be the Meridian line, ſhewing the 12. houre. Againe place one foot in the point A. drawing with the other a light line from C. to D. then one foot being ſet in B. you may try with the other, as before, the truth of the line laſt made. Now where theſe two lines cut each other in the bottome of the plat, place the letter E. Then dividing the quadrant A.E. into 90.^{d} and accounting herein the Elevation of the Pole from E. toward A. make the point F. by which the arke line of ♈ and ♎ repreſenting the Equinoctiall circle, ſhall be drawne. Afterward ſeek out the greateſt declination of the Sunne from the Equator, (which you ſhall finde in the table of the Declination of the Sun) which is 23.^{d} 30.^{m} The account 23.^{d} 30.^{m} from F. toward E. making there a marke for the arke of Cancer. Likewiſe from F. toward A. number the ſame diſtance, for the arke line of Capricorn. This done, account from F. toward E. 20.^{d} 12.^{m} make there alſo a mark for the line ♊ and ♌. And the like ſpace from F. towards A. for the Arke of ♒ and ♐. To conclude, number from F. towards E. 11.^{d}.30.^{m}. making there alſo a marke for the line of ♉ and ♍. and ſo much from F. towards A. for ♓ and ♏.

When you have thus made markes for all the Arkes of the 12 Signes, open your Compaſſes to the Quadrant of the Sphere that is from A. to C. which wideneſſe of the Compaſſes remaining, place one foot in the point F. in the Arke of ♈ and ♎ in the Meridian: and where the other foot ſhall touch the ſame Meridian towards B. make the point G. which ſhall repreſent the Pole antartike, by which as it were from a centre, draw a line from the point D. by F. to C. which ſhall be the line of Aries and Libra. Then one foote of your Compaſſes remaining in the point G. with the other draw lines from one ſide of the plat to the other, by every marke before made for the 12 Sines of Zodiake.

The 12 Sines being hus finiſhed, proceede to the diviſion of the equall houres on this manner. Divide the Arke of the Equator into 12 equall parts, beginning at D. by F. ending in C. Then open your compaſſes to the Quadrant of the plat, and the ſame wideneſſe of them remaining, place one foote on the firſt point of the diviſion next C. in the Equator, and if you have divided the Equator equally, the other foote will touch the firſt part beyond F. towards D. by which from the centre G. to the edge of the plat, draw a line, which ſhall ſhew the firſt houre afternoone. This done, remove your Compaſſes (that wideneſſe remaining) placing one foote in the ſecond part from C. towards F. and the other foote touching the ſecond part from F. towards D. make a line as before, from the centre G. to the brimme of the plat, to ſhew the ſecond houre afternoone. In like manner finig all the other houre lines, namely the 3.4,5 6,7,8, for the afternoone. Then doe likewiſe on the other ſide for the houres in the forenoone, namely the 11 10 9,8,7,6,5, and 4 drawing lines from the centre G. by every diviſion, to the brimme of the plat, &c.

The placing of the unequall houres in this Diall.

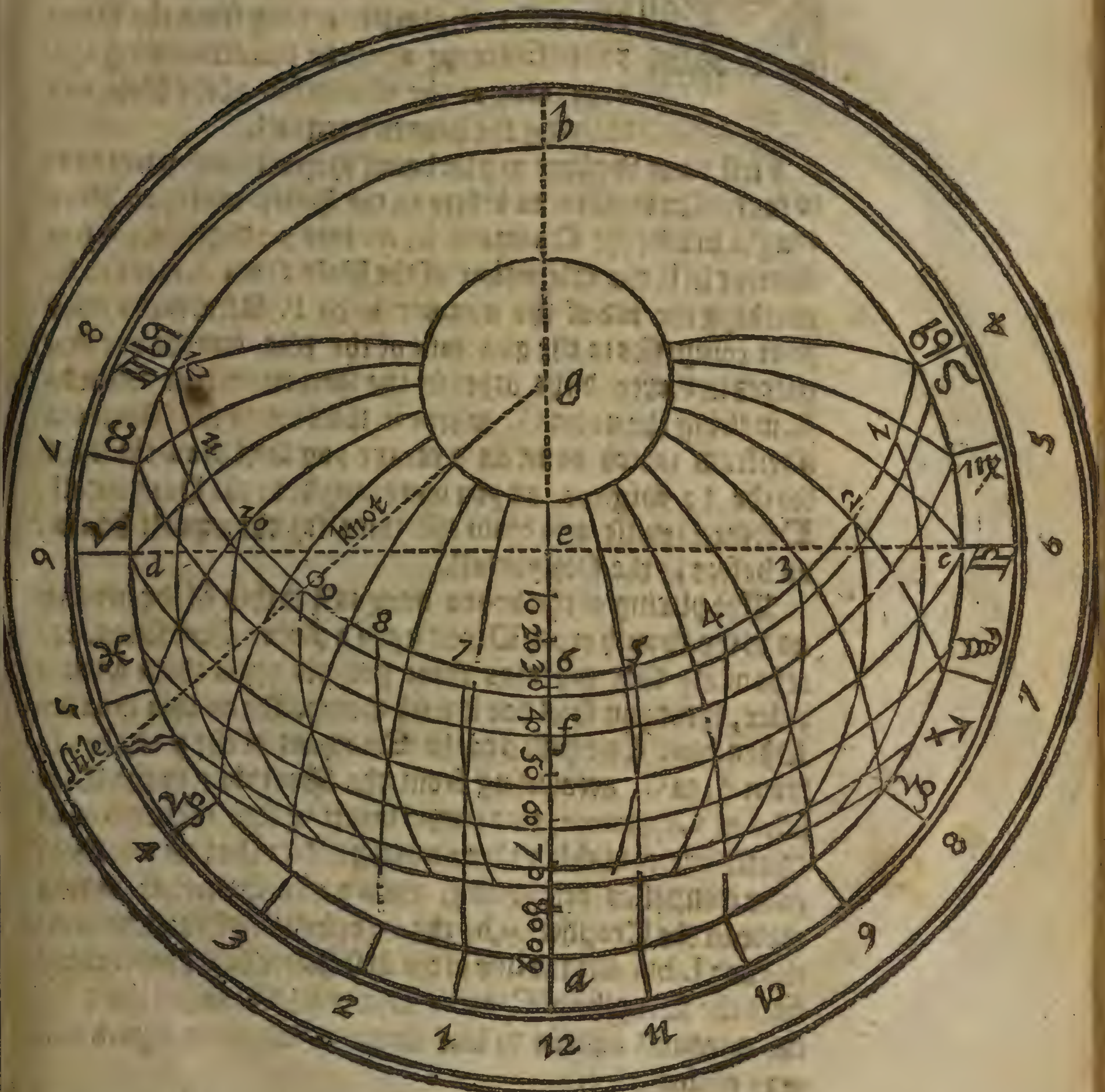
When you will place the houres unequall in this Sphericall Diall, divide the Tropike of Cancer and Capricorne each of them into 12. equall parts, as before you did the Equator for the equall houres. Then with the Compaſſes ioyne each three points of theſe three Arkes, anſwerable into one line or Arke, untill you have made 12. lines to ſhew the 12 unequall houres, as in the Figure following you may ſee. Whereof the Meridian, or 12 unequall houre ſhall alwayes be the 6 unequall houre.

In placing the figures to the equall and unequall houres, and the Caracters to the 12 Signes of the Zodiake, the figure may ſufficiently ſhew, notwithſtanding you may place them where you will giving to each ſigne his proper Caracter, and every houre equall and unequall their proper figures or names.

Fixe the Stile in the centre G. ſtanding up ſo high as the brimme of the plat, ſo that the upper end may appeare as the centre of the circumference, which you may try, by placing a ruler upon the points A.B, And againe upon C, D. In like manner you may examine it with your Compaſſes, but the former, as practice will teach you, is the more convenient way.

You may, if you will, have the Stile ſtand above the plat ſo that it may ſhew the equall houres above the edge of the Sphere, and then faſten a knot of equall height with the plat, which ſhall ſhew the motion of the Sunne in the 12 Signes and the unequal houres, which otherwiſe the ẽd of the Stile ſhould doe: as in the Figure following you may perceive.

The Figure of an hollow Horizontall Diall.



The making of a South Sphericall erect direct Diall.

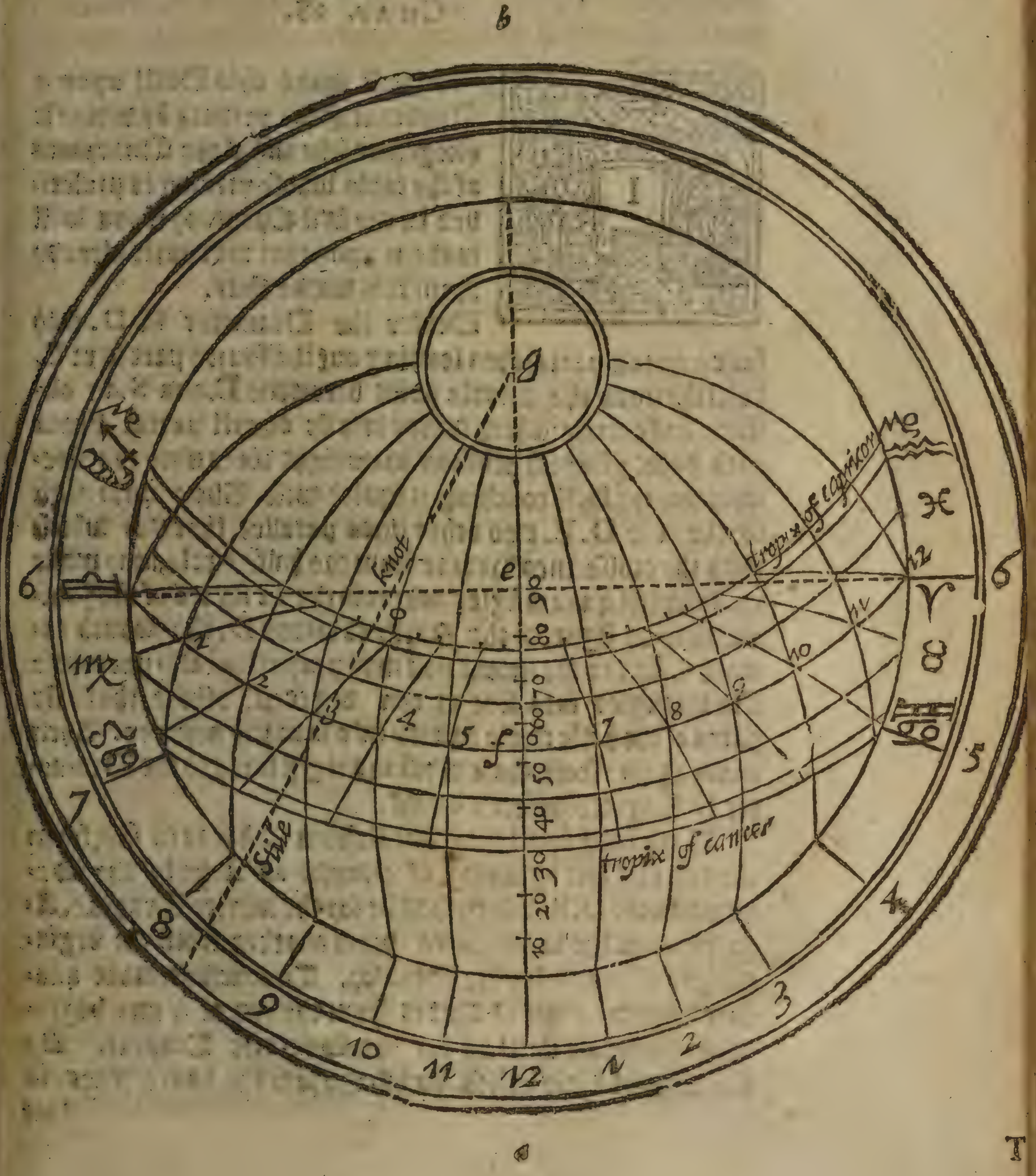
Chap. 27.

You ſhall underſtand, that the making of this kind differeth almoſt nothing from the Horizontall: except onely in the accounting the beginning of the Elevation of the Pole, and drawing the houres unequall.

Firſt, your Sphere or plat being prepared, and parted into foure Quadrants, as before in the Horizontall you were taught, divide the Quadrant E. A. into 90 degrees. Then number in it the Elevation of the Pole from A. toward E. marking the end of the number with F. Afterward open your compaſſes to the quadrant of the plat, and the one foot placed in F. extend the other in the Meridian line towards B. making the point G. where it ſhall touch the Meridian line: from which point as a centre you ſhall draw the lines for the 12 Signes, as you were taught in the Horizontall. Divide likewiſe, and draw the lines for the equall hours, as before in the Horizontall.

The placing of the hours unequall in this kinde is done
as in the South erect Direct upon a plaine ſuperficies, ex-
cept onely that whereas there you did draw them with a
ruler, there you ſhall doe it with Compaſſes on this manner
Open your Compaſſes to the Quadrant of the plat, that is
from A. to C. accounting from the Meridian in the Tro-
pike of Capricorne, two parts wanting two minutes of an
equall houre, making there a marke: And that wideneſſe of
your compaſſes remaining, draw a line from that marke
made in the Tropike ♑, by the interſection of the line of A-
ries and Libra, and the line of the firſt houre in the afternoone
unto the Tropike of Cancer. Draw all the other lines for
the unequall houres in like manner, as in the figure you
may plainely ſee.

Fixe the Stile in the centre G. as you did in the Horizontall, placing the figures for the equall and unequall houres, and the Characters to the 12 Signes, as in the example following, or otherwiſe as you will.



The making of a Diall upon a Quadrant, or the Table deſcribed in the beginning of the Booke.

CHAP. 28.

If you will make this Diall upon a Quadrant alone prepare ãd divide it altogether like one of the Quadrants of the table whoſe making is preſcribed in the firſt Chapt. or if you will make it upon that inſtrumēt already prepared, worke thus.

Divide the Diameter E. D. into foure equall parts; then leaving out the fourth part next E. deſcribe upon the middle point betweene D. and S. an obſcure halfe circle: which divide into ſix equall parts. From each point of which diviſion draw light lines unto the Semidiameter D.E. touching it ſquire-wiſe. Then draw nigh to the line D. E. two other lines parallel thereto: which with the croſſe lines drawne from the halfe circle, may make 12 unequall quadrangles wherein the 12 ſignes of the Zodiake may be figured: the North towards D. the South toward S. And to the intent you may proportionally part thoſe Quadrangles into five or ten degrees, divide thoſe ſix parts of the halfe circle equally into ſo many degrees. Then draw againe from thoſe diviſions right lines to the Diameter D.E. ſquire-wiſe, as before.

This done upon the point E. from S. that is to ſay, from the end of ♐ and bginning of ♑, draw an Arke to the Semidiameter D.E. which ſhall be for the winter Tropike. Againe upon the ſame centre, draw another from the beginning of ♈ and ♎ for the Equator. To conclude, make another from the angle D. that is from the end of ♊ and beginning of ♋ which ſhall be for the Summer Tropike. By the helpe of theſe arkes, you ſhall draw the houre lines, ſo that you firſt know the height of the Sunne above the Horizon at every houre, when it occupieth the beginning of ♑ ♈, and ♋. Whoſe altitude is thus found out.

Take the Elevation of the Pole, and the Complement thereof, alſo the declination of the Sunne from the Equinoctiall, and the diſtance of the Sunne from the Meridian, accounting 15 degrees for every houre, with the Complement of this diſtance. Then if you deſire to know the altitude of the Sunne at ſix of the clock either in the morning or at evening (at which houre onely in Summer it is above the Horizon) multiply the Sine of the Elevation of the Pole, by the Sine of the declination of the Sunne, dividing the product by the whole Sine, and you ſhall have your deſire.

But if the Sunne ſhall be diſtant from the Meridian fewer houres then ſix, multiply the Sine of this diſtance (giving to every houre 15 degrees) by the Sine of the complement of the altitude of the Pole, and the product hereof divide by the whole Sine. Then take the Arke of the quotient from 90 degrees, and the firſt number found out ſhall remaine, which muſt be kept. Then compare the Sine of this number found out, with the Sine of the Elevation of the Pole, augment the leſſer by the whole Sine dividing the product by the greater: whereof ſhall come a quotient Sine to the Complement of whoſe Arke adde the declination of the Sunne, if it ſhall be in the North ſignes or ſubſtract it from that if it occupieth the South ſignes. And if the number which commeth hereof ſhall be greater than 90, take it from 180, and you ſhall have the ſecond number found out. The Sine of this number found out being multiplied, by the Sine of the firſt number found out ſhall yeeld a product, which part by the whole Sine, and the Arke of the quotient Sine, ſhall ſhew the deſired altitude of the Sunne for the houre propounded.

But if the diſtance of the Sunne from the Meridian ſhall exceede ſixe houres (that is 90 degrees) take the degrees of that diſtance from 180, multiplying the Sine of yͤ remainder by the Sine of the Complement of the altitude of the Pole, dividing the product by the whole Sine, and ſubſtract the Arke of the Quotient from 90, the remainder ſhall be called, Firſt number found out. The Sine of which number found out compared with the Sine of the Elevation of the Pole increaſeth the leſſer by the whole Sine, and diſtribute the product by the greater. Then take the Complement of the Declination of the Sun, from the Arke of the quotient, and you ſhall have the ſecond number found out.

Finally, the Sine of the firſt number found out and the Sine of the ſecond being multiplyed by themſelves, and the product parted by the whole Sine; the quotient Sine ſhall yeeld an Arke, which ſhall be the altitude of the Sunne.

But when the Sunne occupieth the beginning of ♈ or ♎ you ſhall finde the altitude thereof every houre, onely by multiplying the Sine of the Complement of the diſtance of the Sunne from the Meridian, by the Sine of the Complement of the Elevation of the Pole, dividing the product by the whole Sine, the quotient which commeth hereof ſhall yeeld the Arke of your deſire. At both the ſix houres, becauſe the one ſixe is the riſing and the other the ſetting, there is then no altitude of the Sunne above the Horizon.

Moreover, to know how much the Meridian altitude is, of the Sunne entring into ♋, adde the greateſt Declination thereof, to the Complement of the Elevation of the Pole: and by ſubſtracting the greateſt Declination of the Sunne from the Complement of the Elevation of yͤ Pole, you ſhall likewiſe have the Meridian altitude of the Sun entring into ♑.

You ſhall likewiſe ſeeke the height of the Sunne, being in the 10 degrees of ♉ above the Horizon, at 8 of the clock before noone, and at 4 after noone, at 7 in the morning, and 5 in the evening: at both 6 and the 5 houre in the morning and 7 at night. Alſo at 5 in the morning and 7 in the evening the Sunne being in the beginning of ♊.

But becauſe the working of this, to find out theſe altitudes, requireth much time and labour, wee will ſet down theſe diſtances ready found out, calculated for the Elevation of the Pole 50.^{d}. and 52.^{d}. which you may likewiſe uſe without any notable difference, where the Pole is Elevated 49.^{d}. 51.^{d}. and 53.^{d}.

The firſt Table calculated for 50. *degrees*

Hour.	Hour.	♋		♈♎		♑		10 d ♉		10 d. ♊	
		D.	M.	D.	M.	D.	M	D.	M.	D.	M.
	12	63	20	40	0	16	30				
11	1	61	2	38	23	15.	19				
10	2	54	42	33	50	11.	51				
9	3	46	15	27	2	6	24				
8	4	36	53	18	45			30	23		
7	5	27	15	9	35			20.	55		
6	6	17	47	0	0			11.	19		
5	7	8	48					2	3	7	14
4	8	0	26							0	0

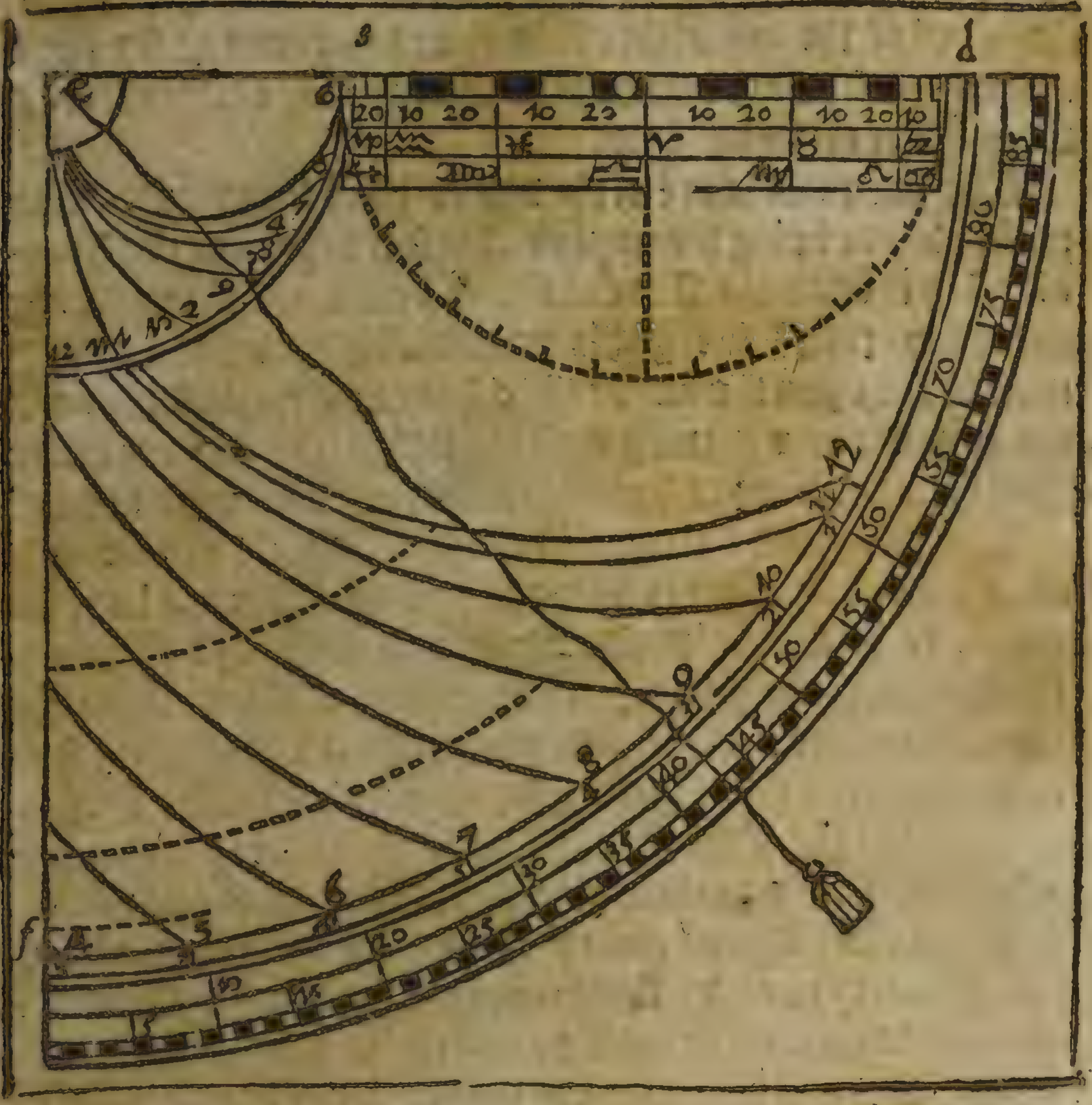
The ſecond Table calculated for 50. degrees of latitude.

Hour.	Hour.	♋		♈ ♎		♑		10 d ♉		10 d. ♊	
		D.	M.	D.	M.	D.	M	D.	M.	D.	M.
	12	61	30	38	0	14	30				
11	1	59	13	36	28	13.	21				
10	2	53	15	32	7	10.	0				
9	3	45	12	25	33	4	45				
8	4	36	12	17	32			29.	36		
7	5	26	53	8	46			19.	22		
6	6	17	42	0	0			11.	4		
5	7	8	58					2	4	7	46
4	8	1	1							0	0

If therefore you will make your Quadrant Horologicall for the elevation of the Pole 50.^{d}. extend a thread, or lay a Ruler from the centre E. by the 63.^{d}. 30.^{m}. of the limbe of the Quadrant, beginning at F. and where the thread ſo placed ſhall touch the Tropike of ♋, there make a point or marke. Againe, let the thread be placed upon the 40.^{d}. of the limbe, and where it ſhall touch the Equator, there alſo make a marke. Thirdly, let the thread be drawn by the 16.^{d} 30.^{m}. of the quadrant: and where it ſhall touch the Tropike of ♑, there make likewiſe a marke. This done, ſearch out the centre (by the 5. Propoſition 4. Euclid) and ioyne theſe three markes into one Arke, which ſhall be the line for the 12. houre. Afterward place the thread upon the 61.^{d}. 2.^{m}. of the limbe, and where it ſhall cut the Tropike of ♋, note it. Draw likewiſe the thread upon the 38.^{d}. 23.^{m}. of the limbe, marke where it cutteth the Equator. Then by the 15.d.19.m. of the limbe extend the thread, making a marke in the ſection thereof and the Tropike of ♑. Draw into one Arke theſe three markes (as you did before) finding out the common centre: ſo ſhall you have the line of the 11 houre before noon, and 1 afternoone. In like manner are the reſt of the houre lines drawn by three points, accounted and found out by the altitude of the Sunne. But becauſe before 9 and after three, in this Elevation of ye Pole, it will not ſerve for this delineation, there muſt another bee made by the Table of the 12 Sines or Quadrangles. Therefore draw that from the 10.d. of ♉, ſo ſhall you have a line or place wherein the third points may be marked. Then to prepare the points of tye Arke for the houre of 8 and 4 of 7 and 5 and both the 6 beſides the two markes made in the Tropike of ♋ and the Equator, let the third be noted in the Arke drawn from the tenth degree of ♉. To draw the line of the 5 and 7 houres, uſe beſides the Tropike of Cancer and this drawn from the 10 degree of ♉, the third which ſhall come from the beginning of ♊. The line of 4 in the morning and 8 in the evening is very ſhort, included in the angle next unto I. Thus you have finiſhed 9 Arkes or lines for the houres, of which each one of them doth ſhew 2 houres: except one which is onely for the 12 houre.

And to the intent that there ſhould be no ſpace left voyd and unprofitable betweene the Tropike of ♑ and the centre E. you may draw in that place the unequall houres, which you ſhall very eaſily doe on this manner. Deſcribe upon the centre E. an Arke very little diſtant from the Tropike of ♑, to be divided into 6 equall parts, and take the middle point betweene the beginning of that Arke at S. and between E. Then upon this point, as it were a centre, make a halfe circle from S. to B. which ſhall bee the line of the 6 unequall houre, that is of midday. Afterward one foote of the Compaſſes being placed in ye ſame Semidiameter E.D. and removeth each way as occaſion ſhall require:

and the other extended in the meane time ſo farre, that it may touch the ſecond point of the Arke divided into 6 parts and the centre E. draw an Arke or line from the centre to that point, which ſhall ſhew the 5 and 7 houres. In like manner are the other 4 drawn, one foote of the Compaſſes being removed, as neceſſity ſhall require in the Semidiameter E.D (which may be prolonged if it ſhall be too ſhort) and the Compaſſes ſo opened, that the other foote may touch ẏ point of the divided Arke and the centre E. and ioyne them all into one Arke line: then fixe a thread in the centre E. well waxed, having two ſmall beades upon it to move with a plummet of iron or lead. Laſt of all prepare two ſights of braſſe or other metall with ioynts, which you muſt place in one right line upon the ſide or edge A. B. ſo that you may direct them, and againe turn them down upon that ſide A B. at your pleaſure: that (if you make this Dial upon the Table or inſtrument preſcribed in the beginning of this book) they be no hindrance to you in trying or examining of your plats. Thus is your Dial prepared: but for further inſtruction behold the Figure.



The uſe of this Diall or Quadrant Horologicall.

TO know the houre of the day when the Sunne ſhineth, work thus. Firſt, ſeek out in ſome Calender in what Signe and degree the Sunne is at that day: then extend the thread with the beads upon the Semidiameter E. D. and place the nethermoſt beade upon that degree, in the Table of the 12 Signes, which the Sunne then occupieth. Afterward lifting up your Quadrant, the thread with the plummet hanging at liberty, let the Sunne beames paſſe through both the ſights, and then the nethermoſt beade ſhall ſhew the houre of the day either before, or after noone: for each line as you ſee, hath two houres, but you may eaſily diſcerne what houre of the day it is.

The unequall houre of the day is thus found out. The nether beade being placed upon his iuſt degree in the Zodiake, lay it upon the Arke of the 12 houre, the thread being extended: thus holding this immoveable, place the uppermoſt beade upon the line of the 6 houre unequall. This done the Sunbeames entring both the ſights, the higheſt beade ſhal ſhew the unequall, and the nethermoſt the equall houre

The riſing and ſetting of the Sunne, whereby the length of the day and night is known, you ſhall finde out on this manner. Place the nether beade upon the iuſt degree of the Sunne in the Zodiake, then extend the thread upon the Semidiameter E.F. of the quadrant and the beade ſhal ſhew at or betweene what houres the Sunne riſeth and falleth.

The height of the Sunne above the Horizon at any time of the day is thus taken: Receive the Sunne beams by the holes in your ſights, and the thread with the plummet having liberty to move, ſhall cut in the limb of the Quadrant the iuſt degree of the altitude of the Sunn above the horizon. In the like manner is the elevation of the Starrs above the Horizon ſearched out.

You ſhall find out the Elevation of the Pole by the helpe of your Quadrant, thus. Take the height of the Sunn at 12 of the clock, when the days and nights be of equall length which being ſubſtracted from 90.^{d} the Elevation remaineth. But if you aſſay that upon any other day than the Equinoctiall, you muſt conſider whether the Sunne occupieth the North, or the South ſignes, and then uſe the table of the Declination of the Sunne on this wiſe. When the Sunne is in the North Signes, ſubſtract his Declination from the Meridian height thereof. But if it be in the South ſignes, adde the declination to his Meridian altitude. The remainder or total Summe being taken from 90.^{d} the Ele-

How

How to make an Inſtrument, whereby you may know the juſt houre of the night by the Starres.

CHAP. 27.

FIrſt prepare a plat or Table of Braſſe or firme and ſolid wood, which will not change or bend, ſomewhat thinne, let the forme of it be round, three inches broad, or more or leſſe as you will. Draw a circle nigh unto the edge, and divide it into 12 equall parts: wherein ſhall bee placed the 12 Signes of the Zodiake, then divide each of theſe parts into 30 equall parts, which ſhall ſhew the num ber of the Dayes that the Sunne moveth in every Signe. Make a ſecond circle, wherein you may number the dayes, and a third circle, wherein write the Characters of the 12 Signes, as you ſee in the Figure following.

Draw likewiſe another circle, wherein you may write the dayes of every moneth in the year, which you may vſe by any Calender, but for more eaſineſſe behold the Table following, whereby you may likewiſe doe it.

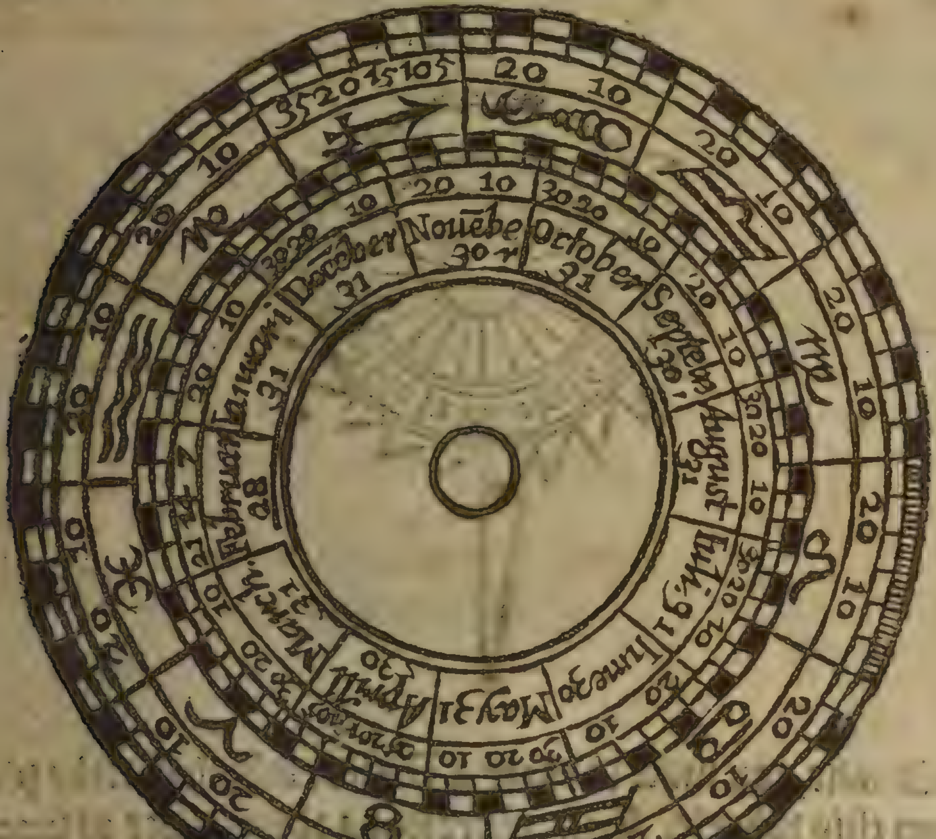
Moneth.	Dayes.	Deg.	M.	Caracters of the 12 Signes.	Signes.
Ianuary	1	20	13	♑	Capricorne
	15	5	33	♒	Aquarius
	31	21	44	♒	
February	14	5	52	♓	Piſces
	28	19	48	♓	
March	15	4	36	♈	Aries
	31	20	18	♈	
Aprill	15	40	51	♉	Taurus
	30	19	53	♉	
May	15	4	38	♊	Gemini
	31	18	50	♊	
Iune	15	3	13	♋	Cancer
	30	17	22	♋	
Iuly	15	1	40	♌	Leo
	31	16	58	♌ ♍	
Auguſt	15	1	24	♍	Virgo
	31	16	38	♎	
Septem.	15	1	40	♎	Libra
	30	16	03	♏	
October	15	1	30	♏	Scorpius
	31	17	43	♐	
November	15	2	33	♐	Sagittarius
	30	8	23	♑	Capricorne
December	15	3	38		

Enter this Table, and you ſhall find that the firſt day of January muſt be placed againſt the 20.^{d}.13.^{m}.of Capricorne, and the 15 day againſt the 5.^{d}.33.^{m}.of Aquarius &c.

Therefore lay your ruler upon the centre A.of your plat and upon the 20.^{d}.13.^{m}.of ♑, and where it ſhall touch the circle which you made for the dayes of every month, there make a marke which ſhall ſhew the firſt day of January. Then lay it upon the 5.^{d}.33.^{m}.of ♒ and the centre A.and where it ſhall touch the circle, make a marke for the 15.day of January. Then lay your ruler upon A.and the 21.^{d}.44.^{m}.of ♒, and make likewiſe a marke for the 31 day of January. Againe place the ruler upon the centre A.and the

5.^{d}.

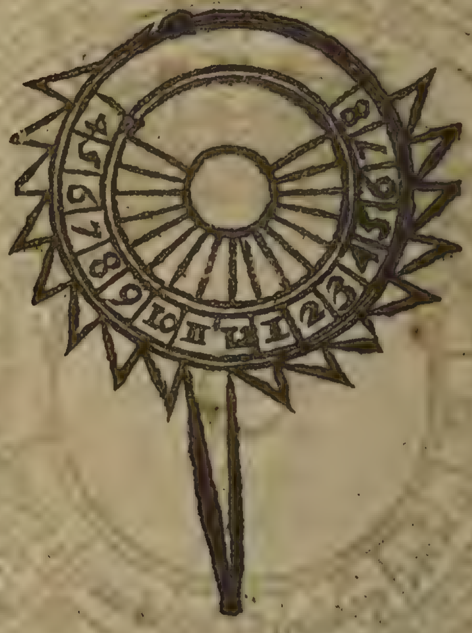
3.^{d}.52.^{m}.of ♓,for the 14 day of February: worke thus with all the reſt, untill you have ſet downe the beginning and middeſt of every month, as the table doth direct you, then having found out the beginning and middeſt of every month you may at eaſe divide every ſpace into ſo many parts, as there be dayes in the month, which it ſerveth for, according as you ſee in this figure following. It ſhall be alſo neceſſary to make one circle to write the number of the dayes of the month, and another for the names of the months: you muſt make alſo a hole in the centre of this plat, of ſuch bigneſſe, as you may ſee a Starre thorow it: as in the Figure you may perceive.



Having prepared this plat with the circles upon it, for the 12 Signes and months you muſt prepare another wheele full of teeth, which you ſhall make on this manner.

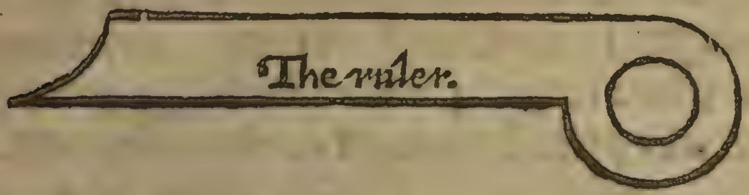
Take a thinne Table or plat of the ſame matter your other was, draw a circle upon it ſo great as the inward circle of the firſt plat, and divide it into 12 equall parts. Then draw lines from the centre to every one of thoſe parts, untill you have ſo many as there be houres in the longeſt night in your Countrey. Then cut teeth by theſe lines for the houres. and write the number of them upon the teeth as you ſee in this Figure. Let the toth for the 12 houre be ſo long from the centre to the end, as it is betweene the centre A. of the other plat, and the circle of the 12 Signes: you muſt likewiſe make a hole in the centre of this wheele, of the ſame bigneſſe of that in the other plat.

The Tothed Wheele.



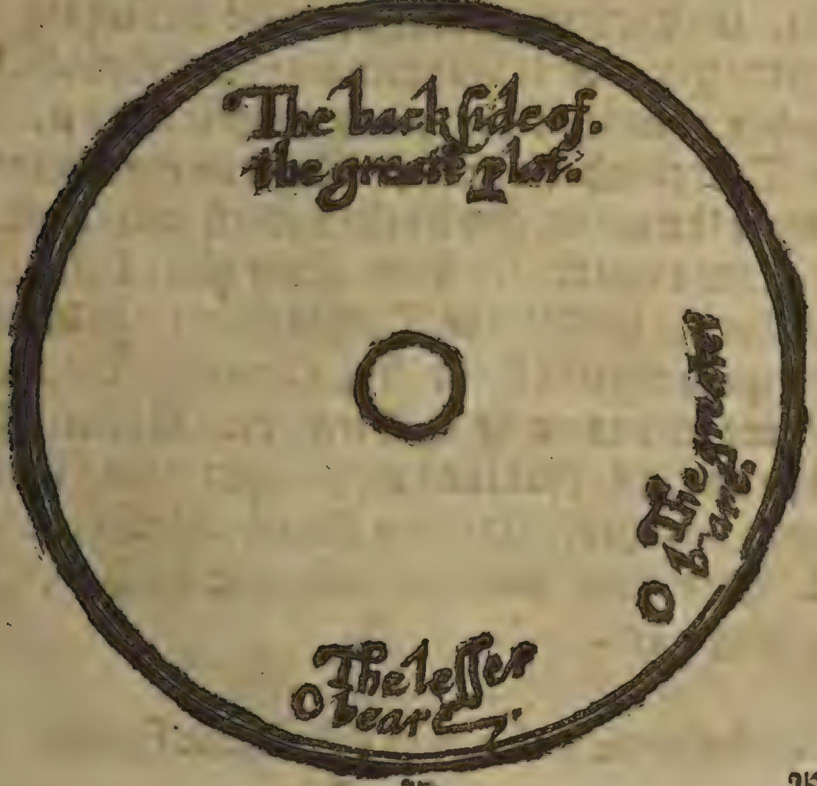
This done, you muſt prepare a Ruler, which ſhall be placed upon this wheele. Take therefore a thinn piece of wood or braſſe and draw upon it a white line: at the one end thereof in the middeſt of the line make a hole of the ſame bigneſſe which that is in the great plat and Tothed wheele. Then draw a circle half an inch wide or more if you will, afterward cut the Ruler round at the end, cutting of likewiſe the one halfe of the breadth of the Ruler by the line.

Let the length of the Ruler from the centre to the end be of ſuch quantity, as is from the centre of the great plat to the outward edge, and an inch or more if you will.



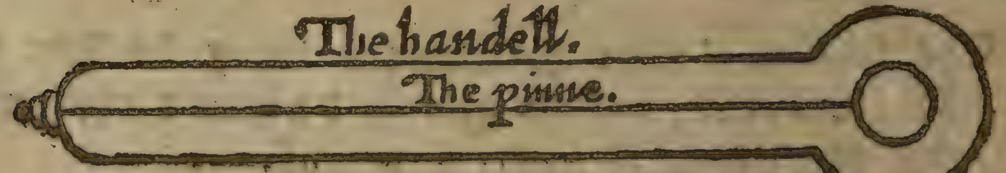
The foreſide of your Inſtrument being finiſhed: the backſide muſt haue two ſwall holes, and a handle, which may turne and moue about. Prepare them thus.

Upon your great plat on the backſide, right againſt the fourth degree of ♍, nigh the edge make a ſmall hole, wherein the little pinne of the handle may be placed, when neede requireth: and write by this the greater Beare. Againe, right againſt the 28.^{d}.1.^{m}. of ♎ on the backſide make another hole likewiſe, ſo that the handle being remoued to it, the pinne may enter as in the other. And by this, write the leſſer Beare, &c.



Prepare for your handle a thinne plat of yron, braſſe, or wood about 6 inches in length or more if you will. Draw in the middeſt of it a line: at the one end thereof make a hole in the middeſt of the line of ſuch bigneſſe as the hole in the greater plat is. Upon this handle you muſt faſten a little ſhort pinne right in the line, ſo that the handle being faſtened with the pinne toward the backſide of the great plat, and being moved, the pinne may fall directly in the hole.

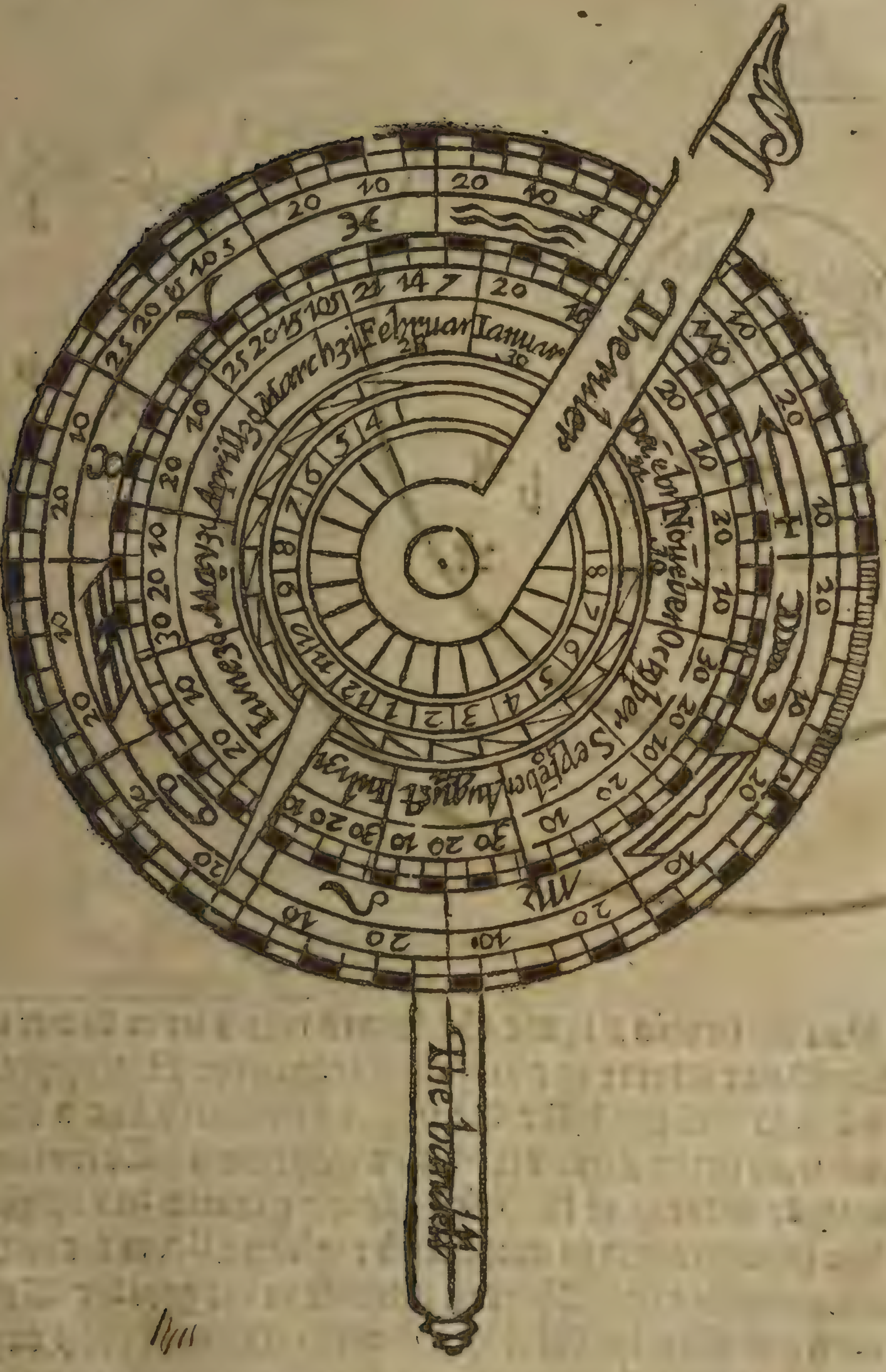
Behold the Figure following



The hollow pinne.

Prepare a hollow pinne of yron or braſſe according to this Figure above, ſo great as it may eaſily enter into the hole of the handle, ſo that it may turne upon it: but let it goe cloſe into the great plat, that it may remaine immoveable. Let the Tothed wheele and the ruler move likewiſe upon it. Then place the Tothed wheele and the Ruler on the former ſide of the plat upon the pinne, and on the backeſide the handle with the little pinne towards the back of the plat: faſten them ſo together, that the handle, the Tothed wheele, and the Ruler may turne upon the plat ſeverally, or each by themſelves at your pleaſure, and as neede ſhall require. Notwithſtanding you muſt be carefull, that the hole in your pinne may bee ſo great as you may perfectly ſee the North Starre in the night thorowout. Then your Inſtrument ſhall be finiſhed, whoſe uſe followeth afterward.

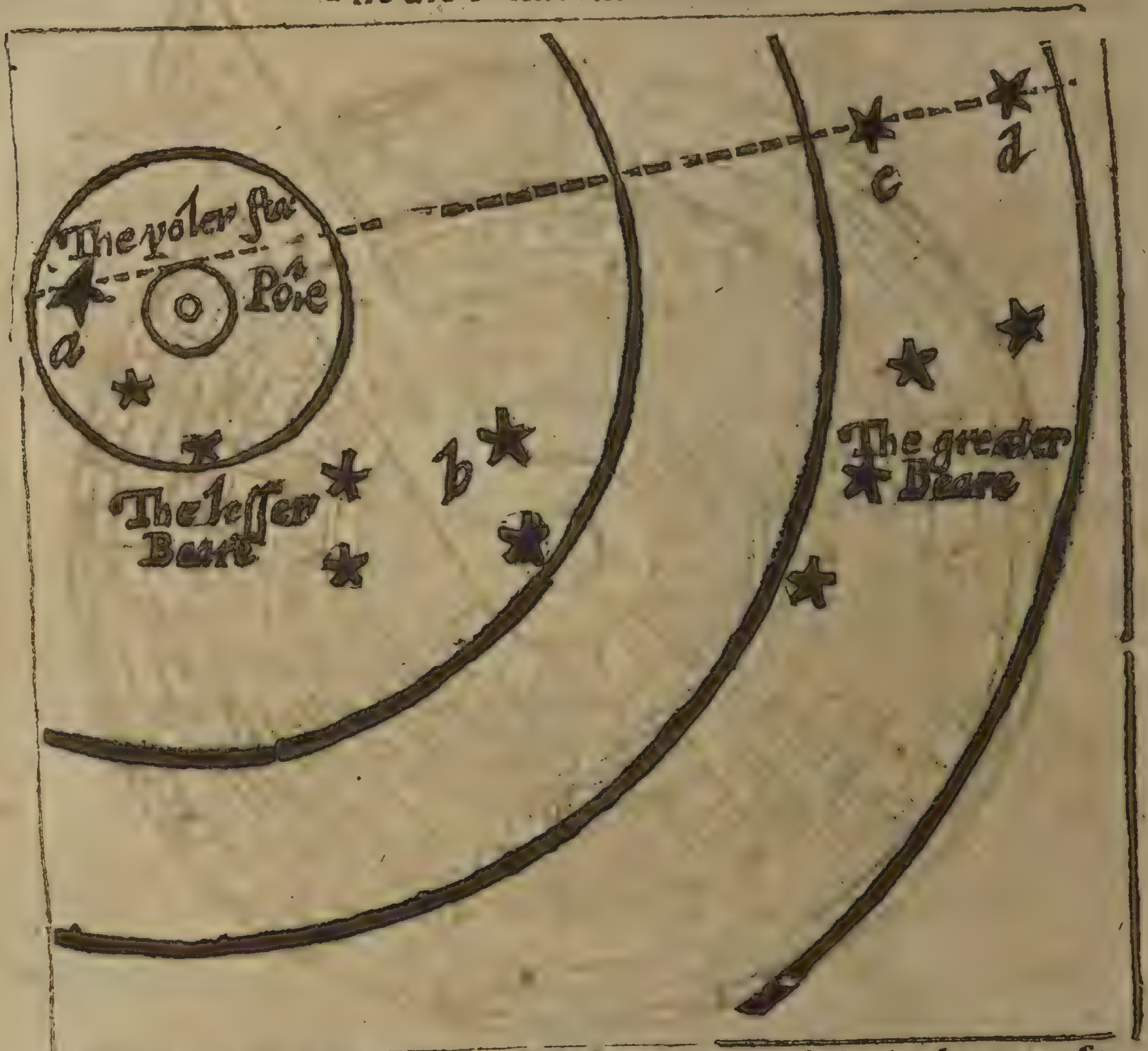
For the better Inſtruction behold the Figure.


The ruler
Januar
Februar
March
Aprill
May
June
Julie
August
September
October
November
December
The handle

The

FIrſt it ſhall be expedient to find out the Starres ſerving to this purpoſe, which you may doe by the Figure following.

The uſe of this Inſtrument.



You ſee in this Figure the Stars which ſerve to our uſe. The Polar Starre is a bright Starre in the North, placed in the tale of the leſſer Beare, and moveth but a ſmall courſe, as in the Figure the letter A. ſheweth There is alſo another Starre of the leſſer Beare greater and brighter than the other, and is noted with the letter B. and ſerveth to this purpoſe alſo. There is likewiſe in the greater Beare called alſo Charles Waine, and of country men the plough, two great bright Starres, and are placed almoſt in a right line with the Polar Starre, and are noted with the letters C.D. And theſe two Starres have 5 other bright Starres by them, but not ſo great as the other bee. Theſe Starres which you ſee in the Figure, as all other, move equally above the Pole, and finiſh their courſe in 24 houres.

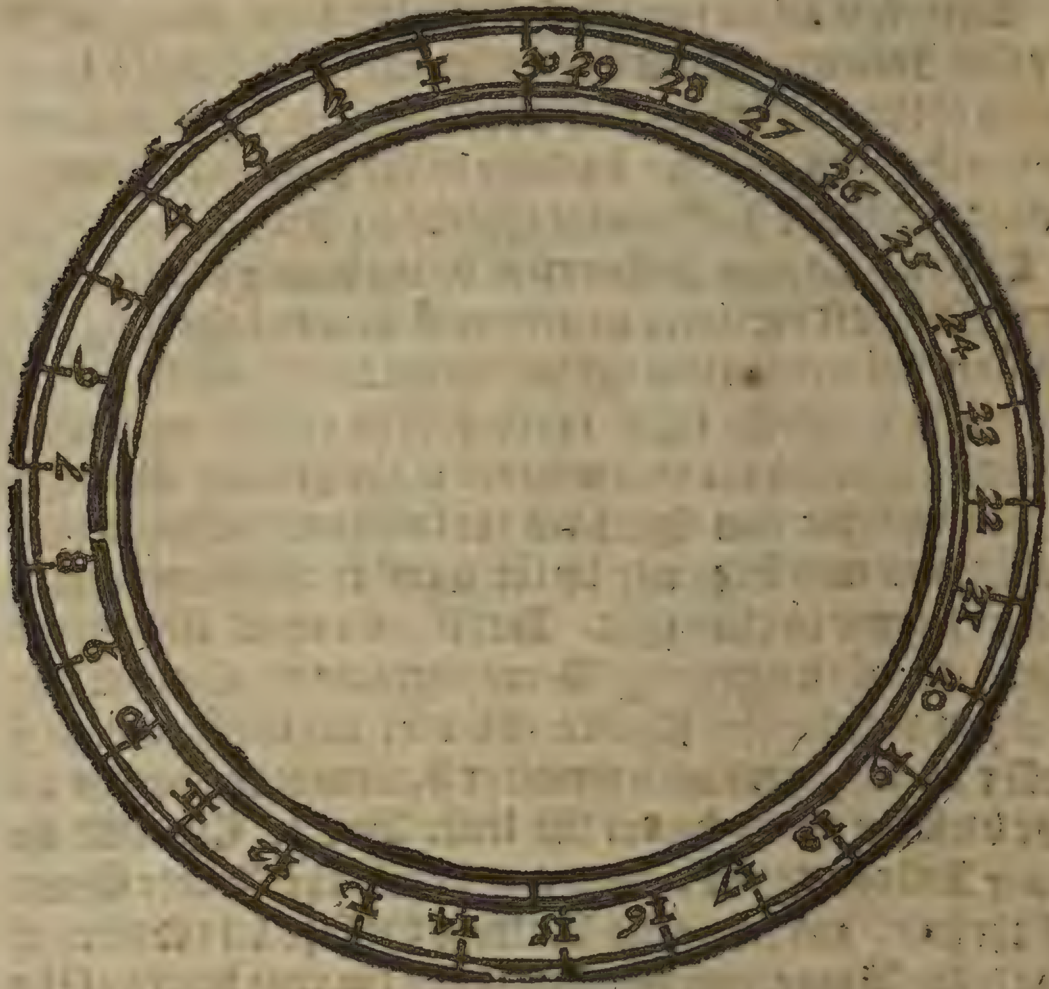
Therefore when you would know the houre of the night by this Inſtrument, doe thus: place the right line of yͤ long tooth of the 12 hour directly over the day of the month, and turne the handle on the backſide to the hole of the greater Beare, and your Inſtrument ſhall be prepared.

Then lift up your Inſtrument by the handle perpendicularly, ſo that it declineth on neither ſides: and beholding the Polare Starre throw the hole in the centre, move yͤ Ruler above, untill the right line thereof be directly againſt, or ſeemeth to touch the two Starres of the greater Beare, & under the line you ſhall have the iuſt houre of the night: which you may finde out by the number of the teeth with your Figure in the night. But if you cannot ſee the two Starres of the greater Beare, becauſe of Clouds: and yet you may ſee the Polare Starre, and the Starre of yͤ leſſer Beare, noted with the letter B. remove the handle on the backſide to the hole of the leſſer Beare. Then lift up your Inſtrument as before, and behold the Polare Starre at the hole, and turne the Ruler to the fore ſaid Starre of the leſſer Beare, and you ſhall finde the true houre of the night, as before is taught.

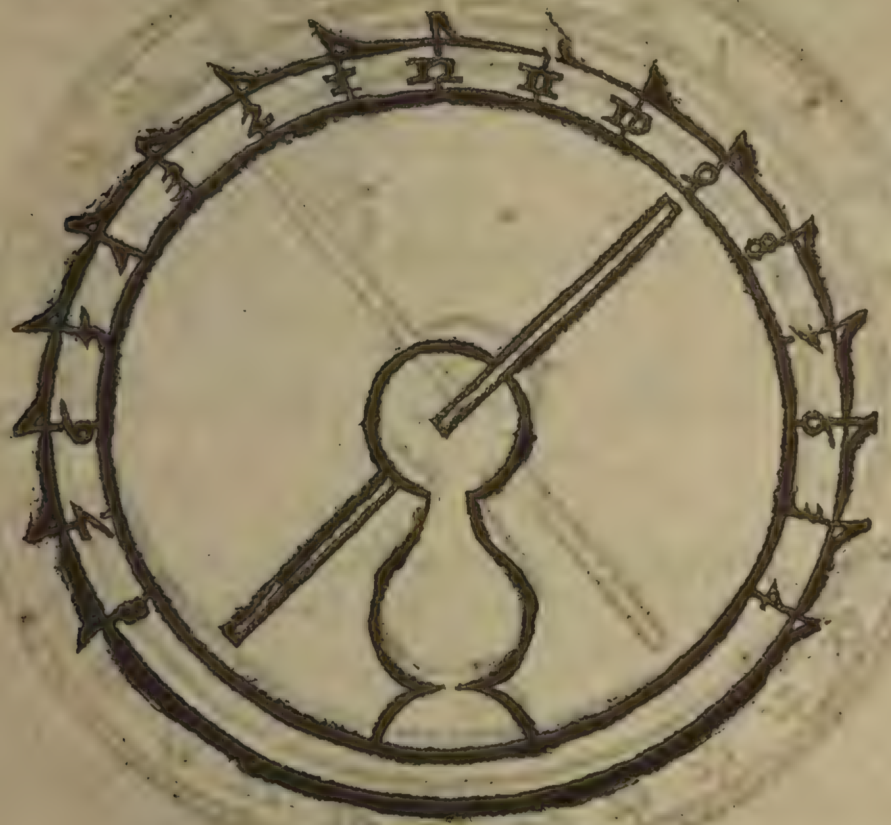
The making of a Diall, to know the houre by the Moone

CHAP. 30.

Prepare a ſquare piece of wood or metal 3 or 4 inches over, draw thereō a circle ſo great as you can, draw alſo another within that. Now becauſe the Moon finiſheth her courſe in 29 days 12 houres, and 44. minutes, part the inward into 30 parts in this manner let 29 be equally divided. & yͤ 30 which is the laſt muſt not be ſo great by a third part: wherefore divide one of theſe 29 equall parts into three parts, and take two of them for the 30. and laſt part.



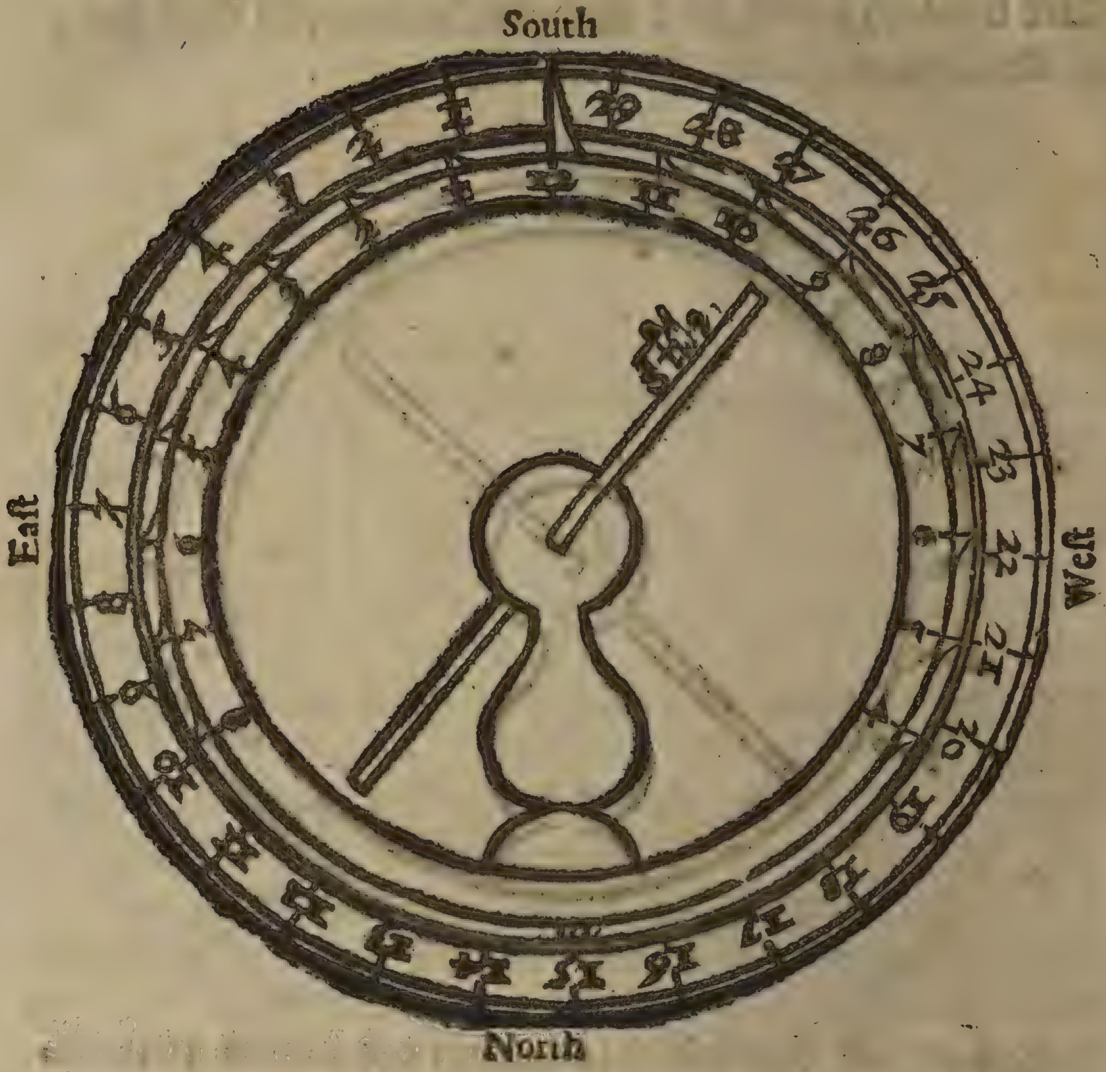
Cut out that which is within the inward limb, and prepare another of the ſame, or like wood or metall ſomewhat thicker, and worke it ſo that it may goe into the former, ſo much of the thickneſſe as it may be equall on the back ſide and that which remaineth of the thickneſſe, let it hang over the foreſide of the firſt plat, to keepe it from falling thorow: draw a circle upon it, and divide it into 24 equall parts. draw from theſe parts houre lines ſo many as ſhall ſuffice for the longeſt night: cut that which overhangeth with teeth at every houre, but eſpecially at the 12 houre make a long tooth, fixe a wyer in the centre for the Stile equally diſtant from the circle on each ſide. Let the Stile hang ſo much beneath yͤ plat, as it is above, becauſe you ſhall haue as much uſe on the backſide as before.



Cut out all that which is within the inward circle except a litle portion to Support the Stile, ſo that this ſhall be but a hoope. Draw the houre lines one the backſide of this plat, as on the foreſide, ſo that one may be right againſt another: then draw lines on the inſide, from every one of theſe lines on the foreſide, to the lines of the backſide. This plat or wheele muſt bee moveable, and turne within the former.

John woodf

His



PLace this Diall that each ſide may behold one quarter of ỹ world preciſely: the South ſide the South, the North ſide the North, &c. Moreover, it muſt recline according to the elevation of the Equinoctiall ſo that the Moone being in the Equinoctiall circle, ſhall give light both above and beneath this Diall. You may place it perfectly with your Inſtrument.

Your Diall being thus placed, when you would know the houre of the night, firſt learne the age of the Moon by an almanack and eſpecially the houre of the change, then turne the great over-hanging tooth, to the day of the Mone on the firſt limb, and the houre of the change, accounting from 12 of the clock.

The ſhadow of the Stile ſhall ſhew the houre of yͤ night either beneath your Diall or elſe above.

This Diall will ſerve alſo for the Sunne, if you turn the great tooth of the moveable wheele to yͤ little ſtrick A. which is right oppoſite to the beginning of the firſt and ēd of yͤ laſt day of the Moone neere the 15.day, and thē it is fit for the Sunne. For it differeth nothing from yͤ North reclining direct, where the Reclination is equall to the Elevation of the Pole.

The uſe of the Table of the declination of the Sunne.

Take what degree you will of any ſigne, & by this table you may know his declination from the Equinoctiall circle. The Signes are written partly on the head of the Table and partly no the foot of the ſame.

The degrees in the firſt columne doe ſerve for the Signes that be on the head of the Table, an the Degrees in the laſt columne doe ſerve for the Signes in yͤ foote of the Table. And the common Area or angle againſt the Signe and the degree which you ſeeke for, doth containe the degrees and minutes of the Declination due to the ſame.

Example

I would know how much the tenth degree of Leo doth decline from the Equinoctiall: I muſt looke in the columne over Leo, right againſt yͤ number of 10. in the laſt columne where I finde 17.^{d}.46.^{m} the declination thereof, &c.

The Table of the declination of the Sunne, from the Equinoctiall circle.

	Aries. *Libra.*		*Taurus.* *Scorpius.*		*Gemini.* *Sagittarius.*		
Deg.	Deg.	M	Deg.	M	Deg.	M	Deg.
1	0	24	11	30	20	12	29
2	0	48	12	11	2	35	28
3	1	12	12	32	20	47	27
4	1	36	12	52	20	58	26
5	1	59	13	12	21	9	25
6	2	23	13	36	21	20	24
7	2	47	13	52	21	30	23
8	3	11	14	12	21	40	22
9	3	34	14	31	21	49	21
10	3	58	14	50	21	58	20
11	4	21	15	9	22	7	19
12	4	45	15	27	22	15	18
13	5	8	15	55	22	23	17
14	5	32	16	3	22	30	16
15	5	55	16	21	22	37	15
16	6	18	16	39	22	44	14
17	6	14	16	56	22	50	13
18	7	4	17	13	22	56	12
19	7	27	17	29	23	1	11
20	7	50	17	46	23	5	10
21	8	12	18	2	3	10	9
22	8	35	18	17	23	13	8
23	8	57	18	33	23	17	7
24	9	10	18	48	23	20	6
25	9	41	19	2	23	28	5
26	10	3	19	17	23	24	4
27	10	25	19	31	23	26	3
28	10	47	19	40	23	28	2
29	11	8	19	50	23	29	1
30	11	29	20	12	23	30	0
Deg.	Deg.	M	Deg.	M	Deg.	M	Deg
	Virgo. *Piſces.*		*Leo.* *Aquarius.*		*Cancer.* *Capricorne.*		

The Table of Sines.

The whole Sine conteineth 100000. parts.

The uſe of the table of Sines.

WHereas the making of ſome Dialls, and this Table of Sines may ſeeme obſcure and hard to them who are not acquainted with Sinicall computation, it ſhall be expedient to declare the uſe hereof, ſo much as pertaineth to the underſtanding of this booke, omitting all other uſes as impertinent to our preſent purpoſe. Wherefore know that the Grades or Degrees are found in the upper head of this Table, and the Minutes pertaining to the degres on yͤ left ſide, & in the Area or common meeting of thẽ both, a number which is called the Sine, anſwerable to each Degree and Minute: offereth it ſelfe. Againe, the Sine being found out, you may eaſily know the Arke, that is, the Degree and Minutes thereof, theſe being on the left hand, the other on the head or upper part. Underſtand by the Complement that which remaineth of any number being taken or ſubſtracted from 90 Degrees. If at any time you enter the Table with iuſt Degrees without any minutes, reſolve one Degree into 60 minutes, and then ſeeke out his Sine. And whereas you ſhall finde ſome numbers imperfect, you muſt remember to ſupply their want with thoſe which be perfect immediately going before.

Example.

The Elevation of the Pole at Cambr. is 52. Degrees, whoſe Sine I deſire to know, therefore reſolving one of the Degrees into Minutes, I enter yͤ Table with 51 Degrees,

grees,60.Minutes, and the common Area I find the Signe to be 78801. If then you deſire to know the complement of this elevation, ſubſtract 52. out of 90. and the remainder ſhall be 38. the complement thereof and entring the Table with $37^{d}.60^{m}$. you ſhall finde in the Area 66. which number becauſe it is imperfect, you muſt ſupply the want thereof by adding yͤ 3. former figures in that which is next before perfect, to wit, 615. and then the whole number ſhall be 61566 the Signe of $38.^{d}$. Which is the Complement of $52.^{d}$. the Elevation of the Pole.

Theſe things well conſidered, there is nothing in yͤ book ſo obſcure, but it ſhall ſeeme plaine and eaſie.

Μελέτη πάντα δύναται.

FINIS:

D	0	1	2	3	4	5
M	*Parts*	*Parts*	*Parts*	*Parts*	*Parts*	*Parts*
1	29	1774	3519	5262	7004	8744
2	58	1803	48	91	33	73
3	87	32	77	5320	62	8803
4	116	61	3606	49	19	31
5	45	90	35	78	7120	60
6	74	1919	64	5407	49	89
7	203	48	93	36	78	8918
8	32	77	3722	65	7207	47
9	61	2007	51	95	36	76
10	90	36	80	5524	65	9005
11	319	65	3809	53	94	34
12	49	94	38	82	7323	63
13	78	2123	67	5611	52	92
14	407	52	96	40	81	9121
15	36	81	3925	69	7410	50
16	65	2210	55	98	39	79
17	94	39	84	5727	68	9208
18	523	68	4013	56	97	37
19	52	97	42	85	7526	66
20	81	2326	71	5814	55	94
21	610	55	4100	43	84	9323
22	39	85	29	72	7613	52
23	69	2414	58	5901	42	81
24	98	43	87	30	71	9410
25	727	72	4216	59	7700	39
26	56	2501	45	88	29	68
27	85	30	74	6017	58	97
28	814	59	4303	46	87	9526
29	43	88	32	75	7816	55
30	73	2617	61	6104	45	84

D	0	1	2	3	4	5
M	Parts.	Parts,	Parts.	Parts.	Parts.	Parts.
31	901	2646	4391	6133	7874	9613
32	30	75	4420	62	7903	42
33	59	2704	49	91	32	71
34	89	34	78	6220	61	9700
45	1015	63	4507	60	90	29
36	47	92	36	79	8019	58
37	76	2821	65	6308	48	87
38	1105	50	95	37	77	9816
39	34	79	4622	66	8106	45
40	63	2908	52	95	35	74
41	92	37	81	6424	64	9903
42	1221	66	4710	53	93	31
43	50	95	39	82	8222	60
44	79	3034	68	6511	51	89
45	1208	53	97	40	80	10018
46	38	82	4826	69	8309	47
47	67	3119	55	98	38	76
48	96	41	84	6627	67	10105
49	1425	70	4914	56	96	34
50	54	99	43	84	8425	65
51	83	3228	72	6714	54	92
52	15:2	57	5001	43	83	10221
53	41	8:	30	72	8512	50
54	70	3315	59	6801	31	79
55	99	44	88	30	70	10308
56	1628	73	5117	59	99	37
57	57	3402	46	88	8628	69
58	87	31	75	6917	57	94
59	1716	60	5204	46	86	10423
60	45	89	33	75	8715	52

D	6	7	8	9	10	11
M	*Parts.*	*Parts.*	*Parts.*	*Parts.*	*Parts.*	*Parts.*
1	10481	12215	13946	15672	17393	19109
2	10510	44	74	15700	17422	38
3	39	73	14003	29	50	66
4	68	12302	32	57	97	95
5	97	31	61	87	17508	19223
6	10626	60	90	15801	36	52
7	55	89	14118	44	65	80
8	84	12417	47	73	93	13909
9	10713	46	76	15901	17622	37
10	42	75	14205	30	51	66
11	71	12504	34	59	79	94
12	99	33	62	88	17708	19423
13	10828	62	91	16016	37	51
14	57	91	14320	45	65	80
15	80	12619	94	74	94	19500
16	10915	48	78	16102	17822	37
17	44	77	14406	31	51	66
18	73	12706	35	60	80	94
19	11002	35	64	89	17908	19623
20	31	64	93	16217	37	51
21	60	93	14521	46	66	80
22	89	12821	50	75	94	19708
23	11116	50	79	16303	18023	37
24	46	79	14608	32	51	65
25	75	12908	37	61	80	95
26	11204	37	65	89	18109	19822
27	33	66	94	16418	37	51
28	62	94	14723	47	66	79
29	91	13023	52	76	94	19908
30	11320	52	80	16504	18223	36

D	6	7	8	9	10	11
M	Parts.	Parts.	Parts.	Parts.	Parts.	Parts.
31	11349	13081	14809	16523	18252	19965
32	78	13110	38	62	80	93
33	11407	39	67	90	18309	20022
34	35	67	96	16619	37	50
35	64	96	14924	48	66	79
36	93	13225	53	76	95	20107
37	11522	54	82	16705	18423	36
38	51	83	15011	34	52	64
39	80	13312	39	62	80	93
40	11609	40	68	91	18509	20221
41	38	69	97	16820	38	50
42	67	98	15126	48	66	78
43	95	13427	54	77	95	20,07
44	11724	56	83	16906	18623	35
45	53	85	15212	34	52	64
46	82	13513	41	63	80	92
47	11811	42	69	92	18709	20421
48	40	71	98	17020	38	49
49	69	13600	15327	49	66	78
50	98	26	56	78	95	20506
51	11927	58	84	17106	18823	35
52	55	86	15413	35	52	63
53	84	13725	42	64	80	93
54	12013	44	71	92	18909	20920
55	42	73	99	17221	38	48
56	71	13802	15528	50	65	77
57	12100	30	57	78	99	20705
58	29	59	85	17307	19023	34
59	58	88	15614	36	52	62
60	86	13917	43	64	80	91

D	12	13	14	15	16	17
M	*Parts.*	*Parts.*	*Parts.*	*Parts.*	*Parts.*	*Parts.*
1	20819	22523	24220	25910	27591	29264
2	48	51	48	38	27619	92
3	76	80	76	66	47	29320
4	20904	22608	24305	94	75	48
5	33	36	33	26022	27703	76
6	61	65	61	50	31	29404
7	90	93	89	78	59	31
8	21018	22721	24417	26105	87	59
9	47	50	46	34	27815	87
10	75	78	74	62	43	29515
11	21104	22806	24502	90	71	43
12	32	35	30	26218	66	70
13	60	63	58	46	27927	98
14	89	91	87	75	54	29626
15	21217	22920	24615	26303	82	54
16	46	48	43	31	28010	81
17	74	76	71	59	38	29709
18	21303	23004	99	87	66	37
19	31	33	24728	26415	94	65
20	59	61	56	43	28122	93
21	88	89	84	71	50	29820
22	21416	23118	24812	99	78	48
23	45	49	40	26527	28206	76
24	73	74	69	55	34	29904
25	21501	23203	97	83	62	31
26	30	31	24925	26611	89	59
27	58	59	53	39	28317	87
28	87	87	81	67	47	30015
29	21615	23316	25009	95	73	42
30	43	44	38	26723	28401	70

D	12	13	14	15	16	17
M	*Parts*	*Parts*	*Parts*	*Parts*	*Parts*	*Parts*
31	21672	23372	25066	26751	28429	30098
32	21700	27401	94	79	57	30126
33	29	29	25122	26807	85	53
34	57	57	50	35	28513	81
35	85	85	78	63	40	30209
36	21814	23514	25206	91	68	36
37	42	42	35	26920	96	64
38	71	70	63	48	28624	92
39	99	99	94	76	52	30320
40	21927	23627	25319	27004	80	47
41	56	55	47	32	28708	75
42	84	83	75	60	36	30402
43	22013	23712	25403	88	63	31
44	41	40	32	27116	91	58
45	69	68	60	44	28819	86
46	98	96	88	72	47	30514
47	22126	23825	25516	27200	75	41
48	54	53	44	28	28903	69
49	83	81	72	56	31	97
50	22211	23909	25600	84	58	30654
51	39	38	28	17311	86	52
52	68	66	57	39	29014	80
53	96	94	85	67	42	30707
54	22325	24022	25713	95	70	35
55	53	51	41	27423	98	63
56	81	79	69	51	29125	91
57	22410	24107	97	79	53	30818
58	38	35	25825	27507	81	46
59	66	63	53	35	29209	74
60	95	92	81	63	37	30901

D	18	19	20	21	22	23
M	Parts.	Parts.	Parts	Parts.	Parts.	Parts
1	30929	32584	34229	35863	37487	39909
2	57	32611	56	91	47514	39126
3	84	39	84	35918	41	53
4	31012	66	34311	45	68	80
5	39	94	38	72	95	39206
6	67	32721	65	99	37622	33
7	95	49	93	36029	49	60
8	31122	76	34420	53	76	87
9	50	32804	47	81	37703	39313
10	78	31	75	36108	30	40
11	31205	59	34502	35	57	67
12	33	86	29	62	84	94
13	61	32914	57	89	37811	39420
14	88	41	84	36216	37	47
15	31316	69	34611	43	64	74
16	44	96	39	70	91	39501
17	71	33023	66	98	37918	27
18	99	51	93	36325	45	54
19	31426	78	34720	52	72	81
20	54	33106	48	79	99	39607
21	82	33	75	36406	38026	34
22	31509	61	34802	33	53	61
23	37	88	29	60	80	88
24	64	33216	57	87	38107	39714
25	92	43	84	36514	33	41
26	31620	70	34911	41	60	68
27	47	98	38	68	87	94
28	75	33325	66	95	38214	39821
29	31702	53	93	36623	41	48
30	30	80	35020	50	68	74

D	18	19	20	21	22	23
M	*Parts.*	*Parts.*	*Parts*	*Parts.*	*Parts.*	*Parts.*
31	31758	33408	25047	36677	38295	39901
32	85	35	75	36704	38322	28
33	31831	62	35102	31	48	54
34	40	90	29	58	75	81
35	68	33517	56	85	38401	40008
36	95	45	84	36812	29	34
37	31923	72	35211	39	56	61
38	51	99	38	66	83	88
39	78	33627	65	93	38510	40114
40	32006	54	93	36920	36	41
41	33	82	35320	47	63	68
42	61	33709	47	74	90	94
43	88	36	74	37001	38617	40221
44	32116	62	35401	28	44	48
45	43	91	29	55	71	74
46	71	33819	56	82	97	49301
47	99	46	83	37109	38724	27
48	32226	73	35510	36	51	54
49	54	33901	37	63	78	81
50	81	28	75	90	38805	40407
51	32309	55	92	37217	31	34
52	36	83	35619	44	58	60
53	64	34010	46	71	85	87
54	91	37	73	98	38912	40514
55	32419	65	35700	37325	49	40
56	46	92	28	46	65	67
57	74	34119	55	79	92	93
58	32501	47	82	37406	39019	40620
59	29	74	35809	33	46	47
60	56	34202	36	60	73	73

D	24	25	26	27	28	29
M	*Parts.*	*Parts.*	*Parts.*	*Parts.*	*Parts.*	*Parts.*
1	40707	42288	43863	45424	46972	48506
2	26	42314	89	50	98	31
3	53	40	43915	76	47024	57
4	79	67	41	45502	49	82
5	40806	93	67	28	75	48608
6	33	42419	93	54	47101	33
7	59	46	44020	80	26	58
8	86	72	46	45606	52	84
9	40912	98	72	32	78	48709
10	39	42525	98	58	47203	35
11	65	51	44124	83	29	60
12	92	77	50	45709	55	85
13	41018	42604	76	35	80	48811
14	45	30	44202	61	47306	36
15	71	56	28	87	31	62
16	98	83	54	45813	57	87
17	41124	42709	81	39	83	48912
18	51	35	44307	64	47408	38
19	77	62	33	90	34	63
20	41204	88	59	45916	60	88
21	30	42814	85	42	85	49014
22	57	40	44411	68	47511	39
23	83	67	37	94	36	65
24	41310	93	63	46019	62	90
25	36	42919	89	45	88	49115
26	63	46	44515	71	47613	41
27	89	72	41	97	39	66
28	41416	98	67	46123	64	91
29	42	43024	93	49	90	49217
30	69	51	44619	74	47715	42

D	24	25	26	27	28	29
M	*Parts.*	*Parts.*	*Parts.*	*Parts.*	*Parts.*	*Parts.*
31	41495	43077	44645	46200	47741	49267
32	41522	43103	71	26	67	92
33	48	29	97	52	92	49318
34	75	56	44723	78	47818	43
35	41601	82	49	46303	44	68
36	28	43208	75	29	69	94
37	54	34	44801	55	49	49419
38	80	61	27	81	47920	44
39	41707	87	53	46406	45	70
40	33	43313	79	32	71	95
41	60	39	44905	58	96	49520
42	86	65	31	84	48022	45
43	41813	92	57	46509	47	71
44	39	43418	83	35	73	96
45	65	44	45009	61	98	49621
46	92	70	35	87	48124	46
47	41918	96	61	46612	49	72
48	45	43523	87	38	75	97
49	71	49	45113	64	48200	49822
50	98	75	39	90	26	47
51	42024	43601	65	46715	51	73
52	50	27	91	41	77	98
53	77	54	45317	67	48302	49823
54	42103	80	43	92	28	48
55	29	43706	69	46818	53	73
56	56	32	95	44	79	99
57	82	58	45321	70	48404	49924
58	42209	84	47	95	30	49
59	35	43810	73	46921	55	74
60	61	37	99	47	80	50000

D M	30 *Parts.*	31 *Parts.*	32 *Parts.*	33 *Parts.*	34 *Parts.*	35 *Parts.*
1	50025	51528	53016	54488	55943	57381
2	50	53	41	54512	66	57405
3	75	78	65	37	91	29
4	50100	51603	90	61	56015	52
5	25	28	53115	85	39	76
6	51	53	39	54610	63	57500
7	76	78	64	34	87	24
8	50201	51703	89	58	56112	48
9	26	28	53213	83	36	71
10	51	52	38	54707	60	95
11	76	77	63	31	84	57619
12	50302	51802	87	56	56208	43
13	27	27	53312	80	32	67
14	52	52	36	54804	56	98
15	77	77	61	29	80	57714
16	50402	51902	86	53	56504	38
17	27	27	53410	77	28	62
18	52	51	35	54902	52	85
19	77	76	59	26	76	57809
20	50502	52001	84	50	56400	33
21	28	26	53508	75	24	56
22	53	51	33	99	48	80
23	78	76	58	55023	72	57904
24	50603	52100	82	48	96	28
25	28	25	53607	72	56520	51
26	53	50	31	96	44	75
27	78	75	56	55120	68	99
28	50703	52200	80	45	92	58022
29	28	25	53705	69	56616	46
30	53	49	29	93	40	70

D	30	31	32	33	34	35
M	*Parts.*	*Parts.*	*Parts.*	*Parts.*	*Parts.*	*Parts.*
31	50778	52274	53754	55217	56664	58093
32	50803	99	79	42	88	58117
33	29	52324	53804	66	56712	41
34	54	49	28	90	36	64
35	79	73	52	55314	60	88
36	50904	98	77	39	84	58212
37	29	52423	53901	63	56808	35
38	54	46	26	87	32	59
39	79	72	50	55411	56	83
40	51004	97	75	36	80	58306
41	29	52522	99	60	56904	30
42	54	47	54024	84	27	54
43	79	71	48	55508	51	77
44	51104	96	72	32	75	58401
45	26	52621	97	57	99	24
46	54	46	54121	81	57023	48
47	79	70	46	55605	47	72
48	51204	95	70	29	71	95
49	29	52720	95	53	95	58519
50	54	45	54219	77	55119	42
51	79	69	44	55702	42	66
52	51304	94	68	26	66	90
53	29	52819	93	50	90	58613
54	54	43	54317	74	57214	37
55	79	68	41	98	38	60
56	51404	93	66	55822	62	84
57	28	52917	90	46	86	58707
58	53	42	54415	71	57309	31
59	68	77	39	95	33	54
60	51503	91	63	55919	57	78

D	36	37	38	39	40	41
M	*Parts.*	*Parts.*	*Parts.*	*Parts.*	*Parts.*	*Parts.*
1	58802	60204	61589	62954	64301	65627
2	25	27	61611	77	23	49
3	49	51	34	99	45	71
4	72	74	57	63022	67	93
5	96	97	80	45	90	65715
6	58919	60320	61703	67	64412	35
7	43	44	26	90	34	59
8	66	67	49	63112	56	81
9	90	90	72	35	79	65803
10	59013	60413	95	57	64501	25
11	37	36	61817	80	23	47
12	60	59	40	63202	45	68
13	84	38	63	25	67	90
14	59107	60506	86	48	90	95912
15	30	29	61909	70	64612	34
16	54	52	32	93	34	56
17	77	75	55	63315	56	78
18	59201	98	77	38	78	66000
19	42	60621	62000	60	64701	22
20	48	45	23	83	23	43
21	71	68	46	63405	45	65
22	95	91	69	28	67	87
23	59318	60714	91	50	89	66109
24	41	37	62114	73	64811	31
25	65	60	37	95	34	53
26	88	83	60	63518	56	74
27	59412	60806	83	40	78	96
28	35	29	62205	62	64900	66318
29	58	53	28	85	22	40
30	82	76	51	63607	44	60

D	36	37	38	39	40	41
M	*Parts.*	*Parts.*	*Parts.*	*Parts*	*Parts.*	*Parts.*
31	59505	60899	62274	63630	64966	66283
32	29	60922	96	52	89	66305
33	52	45	62319	75	65011	27
34	75	68	42	97	33	49
35	99	91	65	63719	55	70
36	59622	61014	87	42	77	92
37	45	37	62410	64	99	66414
38	69	60	33	87	65121	36
39	92	83	56	63809	43	57
40	59715	61106	78	32	65	79
41	39	29	62501	54	87	66510
42	62	52	24	76	65209	23
43	85	75	46	99	31	44
44	59809	98	69	63921	53	66
45	32	61221	92	43	75	88
46	55	44	62615	66	98	66609
47	79	67	37	88	65320	31
48	59902	90	60	64010	42	53
49	25	61313	83	33	4	74
50	48	36	62705	55	86	96
51	72	59	28	77	65408	66718
52	55	82	51	64100	30	39
53	60018	61405	73	22	52	61
54	42	28	69	44	74	83
55	65	51	62818	67	96	66804
56	88	74	41	89	65518	26
57	60111	97	64	64211	40	48
58	35	61520	86	34	61	69
59	58	43	62909	56	83	91
60	81	66	32	78	65605	66913

D M	42 *Parts.*	43 *Parts.*	44 *Parts.*	45 *Parts.*	46 *Parts.*	47 *Parts.*
1	66934	68221	69486	70731	71954	73155
2	56	42	69507	51	74	75
3	77	63	28	72	94	94
4	99	84	49	92	72014	73214
5	67021	68306	70	70813	34	34
6	42	27	91	33	55	54
7	64	48	69612	54	75	74
8	85	70	33	75	95	93
9	67107	91	53	95	72115	73313
10	28	80412	74	70916	35	33
11	50	33	95	36	55	53
12	72	45	69716	67	75	72
13	93	75	37	77	96	92
14	67215	97	58	98	72216	73412
15	36	68518	79	71018	26	32
16	58	39	96	39	56	51
17	79	60	66820	56	76	71
18	67301	81	41	79	96	91
19	22	68603	62	71100	72316	73501
20	44	24	83	20	36	30
21	65	45	69903	41	56	50
22	87	66	24	61	77	70
23	67408	87	45	81	97	90
24	30	68708	66	71202	72417	73609
25	51	29	87	23	37	29
26	73	51	70007	43	57	49
27	94	72	28	63	77	68
28	67516	93	49	84	97	88
29	37	68814	70	71304	72517	73708
30	59	35	90	25	37	27

D	42	43	44	45	46	47
M	Parts.	Parts.	Parts.	Parts.	Parts.	Parts.
31	67580	68856	70111	71345	72557	73747
32	67601	77	32	65	77	67
33	23	98	53	86	97	86
34	44	68919	73	71406	72617	73806
35	66	40	94	26	37	25
36	87	61	70215	47	57	45
37	67709	83	36	67	77	65
38	30	69004	56	87	97	84
39	51	25	77	71508	72717	73904
40	73	46	98	28	37	23
41	94	67	70318	48	57	43
42	67815	88	39	69	77	63
43	37	69109	60	89	97	82
44	58	30	80	71609	72817	74002
45	80	51	70401	30	37	21
46	67901	72	22	50	57	41
47	22	93	42	70	76	60
48	44	69214	63	91	96	80
49	65	35	84	71711	72916	74100
50	86	56	70504	31	36	19
51	68008	77	25	51	56	39
52	29	98	45	72	76	58
53	50	69319	66	92	96	78
54	73	40	87	71812	73016	97
55	94	61	70607	32	36	74217
56	68114	82	28	53	45	36
57	35	69403	48	73	75	56
58	56	23	66	93	95	75
59	78	44	90	71913	73115	95
60	99	65	70710	33	53	74314

D	48	49	50	51	52	53
M	*Parts*	*Parts*	*Parts*	*Parts*	*Parts*	*Parts*
1	74333	75490	76623	77732	78818	79881
2	53	75509	41	51	36	98
3	72	28	60	69	54	79916
4	92	47	79	87	72	33
5	74411	66	97	77806	90	51
6	31	85	76716	24	78908	68
7	50	75604	35	42	26	85
8	70	23	53	60	44	80003
9	89	42	72	79	61	20
10	74508	61	91	97	79	38
11	28	80	76809	77915	97	55
12	47	99	28	33	79015	73
13	66	75718	46	52	33	90
14	86	37	65	70	51	80107
15	74605	56	84	88	68	25
16	25	75	76902	78006	86	42
17	44	94	21	24	79104	60
18	63	75813	39	43	22	77
19	83	32	58	19	40	94
20	74702	51	77	79	57	80212
21	21	70	95	97	75	29
22	41	89	77014	78115	93	47
23	60	75908	32	33	79221	64
24	79	27	51	52	81	81
25	99	46	69	70	46	99
26	74818	64	88	88	64	80326
27	37	83	77106	78206	82	33
28	57	76002	25	24	99	51
29	76	21	43	42	79317	68
30	95	12	62	60	35	85

D	48	49	50	51	52	53
M	*Parts.*	*Parts.*	*Parts*	*Parts.*	*Parts.*	*Parts.*
31	74914	76059	77180	78278	79353	80402
32	34	78	99	97		20
33	53	97	77217	78315	88	37
34	72	76116	36	33	79406	54
35	91	43	54	51	23	72
36	75011	53	73	69	41	89
37	30	72	91	87	59	80506
38	49	91	77310	78405	76	23
39	68	76210	28	23	94	41
40	88	29	47	41	79512	58
41	75107	48	65	59	29	75
42	26	66	84	77	47	92
43	45	85	77402	95	64	80610
44	64	76304	20	78513	82	27
45	83	23	39	31	79600	44
46	75203	42	57	49	17	61
47	22	60	76	67	35	78
48	41	79	94	85	52	96
49	60	98	77512	78603	70	80713
50	79	76417	31	21	88	30
51	99	35	49	39	79705	47
52	75318	44	67	57	23	64
53	37	73	86	75	40	81
54	56	92	77604	93	85	98
55	75	76510	22	78711	75	80816
56	94	29	41	29	93	33
57	75413	48	59	47	7981	50
58	32	67	77	65	28	67
59	51	85	96	83	46	84
60	70	76604	77714	78801	63	80901

D	54	55	56	57	58	59
M	*Parts.*	*Parts.*	*Parts.*	*Parts.*	*Parts.*	*Parts.*
1	80918	81931	82920	83882	84820	85731
2	35	48	36	98	35	46
3	52	65	52	83914	51	61
4	70	81	68	30	66	76
5	87	98	85	46	81	91
6	81004	82015	83001	61	97	85806
7	21	31	17	77	84912	21
8	38	48	33	93	27	36
9	55	65	49	84009	43	51
10	72	81	66	25	58	66
11	89	98	82	40	73	81
12	81106	82114	98	56	89	96
13	23	31	83115	72	85004	85910
14	40	48	30	88	91	25
15	57	64	46	88403	35	40
16	74	81	63	19	50	55
17	91	97	79	35	65	70
18	81208	82214	95	51	81	85
19	25	30	93211	66	96	86000
20	42	47	27	82	85111	14
21	59	64	43	98	26	29
22	76	80	59	84213	42	44
23	93	97	76	29	57	59
24	81310	82313	92	54	72	74
25	27	30	83308	60	87	89
26	43	46	24	76	85203	86103
27	60	63	40	92	81	18
28	77	79	65	84370	33	33
29	94	96	72	23	48	48
30	81411	82412	88	39	64	62

D	54	55	56	57	58	59
M	*Parts.*	*Parts,*	*Parts.*	*Parts.*	*Parts.*	*Parts.*
31	81428	82429	83404	84354	85279	86177
32	45	45	20	70	94	92
33	62	62	36	86	85309	86207
34	79	78	52	84401	24	21
45	95	94	68	63	39	36
36	81512	82511	84	32	55	51
37	26	27	83500	48	70	66
38	46	44	16	63	85	80
39	63	60	32	79	85400	95
40	80	77	48	95	15	86310
41	96	93	64	84510	30	24
42	81613	82609	80	26	45	39
43	30	26	96	41	60	54
44	47	42	83612	57	76	68
45	64	58	28	72	91	83
46	80	75	44	88	85506	98
47	97	91	60	84603	21	86412
48	81714	82708	76	19	36	27
49	31	24	92	34	51	42
50	48	40	83708	50	66	56
51	64	57	24	65	81	71
52	81	73	40	81	69	58
53	98	89	55	96	85611	86500
54	81814	82806	71	84712	26	15
55	31	22	87	27	41	29
56	48	38	83803	34	56	44
57	56	54	19	58	71	58
58	81	71	35	73	86	73
59	98	87	51	89	85701	87
60	81915	82903	67	84804	16	86602

D	60	61	62	63	64	65
M	Parts	Parts	Parts	Parts	Parts	Parts
1	86617	87476	88308	89113	89892	90643
2	31	90	22	27	89904	55
3	90	87504	35	40	17	67
4	60	18	88349	53	30	79
5	75	32	62	89166	43	92
6	89	87546	76	79	89955	90704
7	86404	60	90	92	68	16
8	18	74	88403	89206	81	28
9	33	88	17	19	93	41
10	47	87901	30	32	60006	90753
11	62	16	44	45	19	65
12	76	30	88458	89258	31	77
13	91	44	71	71	44	89
14	86805	87658	85	84	90057	90802
15	19	72	98	97	69	14
16	30	86	88512	89310	82	26
17	48	87700	25	24	95	38
18	63	14	39	37	90107	90840
19	77	28	52	50	20	62
20	91	42	88566	89363	32	75
21	86906	87756	79	76	45	87
22	20	70	93	89	98158	99
23	35	84	88606	89402	70	90911
24	49	98	20	15	83	23
25	63	87812	33	28	95	35
26	78	26	47	41	90208	47
27	92	40	88660	89454	20	90959
28	87006	53	74	67	33	71
29	21	67	87	80	46	84
30	35	87881	88701	89493	90258	96

D	60	61	62	63	64	65
M	*Parts.*	*Parts,*	*Parts.*	*Parts.*	*Parts.*	*Parts.*
31	87049	87895	88714	89506	90271	91008
32	64	87909	27	19	83	20
33	78	23	41	32	96	32
34	92	37	54	45	90308	44
45	87107	51	88768	89558	21	91056
36	21	87964	81	71	33	68
37	35	78	94	84	46	80
38	94	92	88808	97	90358	92
39	64	88006	21	80609	70	91104
40	87	20	35	32	83	16
41	92	33	48	35	95	28
42	87206	47	88861	48	90408	40
43	21	88061	75	89661	20	91162
44	35	75	88	74	33	64
45	49	89	88954	87	45	76
46	63	88102	15	89700	90457	88
47	78	16	28	12	70	91200
48	92	30	41	25	82	12
49	87306	44	88901	38	95	23
50	20	88157	68	89751	90507	35
51	34	71	81	64	19	91247
52	48	85	94	77	32	59
53	63	98	89008	89	44	71
54	77	88212	21	89802	90556	83
55	91	26	34	15	69	95
56	87405	40	47	28	81	91307
57	19	53	89060	41	93	19
58	33	88267	74	89853	90606	30
59	47	81	87	66	18	42
60	61	94	89100	79	30	91354

D	66	67	68	69	70	71
M	*Parts.*	*Parts.*	*Parts.*	*Parts.*	*Parts.*	*Parts.*
1	91366	92061	92729	93368	93979	94561
2	78	73	40	78	89	70
3	90	84	51	89	99	80
4	91401	95	61	99	94009	89
5	13	92107	92772	93410	18	99
6	25	18	83	20	28	94608
7	37	29	94	30	38	17
8	81448	41	92805	41	48	27
9	60	92152	16	93451	94058	36
10	72	63	26	61	68	47
11	84	75	37	72	78	94655
12	95	86	92848	82	88	64
13	91507	97	59	92	97	74
14	19	92208	70	93503	94107	83
15	31	20	80	13	17	93
16	42	31	91	23	27	94702
17	91554	42	92902	34	37	11
18	66	92253	13	93544	74	21
19	77	65	24	54	94156	30
20	89	76	34	64	66	39
21	91601	87	92945	75	76	94748
22	12	98	56	83	86	58
23	24	92309	66	95	95	67
24	37	21	77	93605	94205	76
25	91647	32	88	16	15	86
26	59	43	99	26	25	95
27	71	92354	93009	36	34	94804
28	82	65	20	46	44	13
29	94	76	31	57	94254	23
30	91706	92387	93041	67	64	32

D	66	67	68	69	70	71
M	Parts.	Parts.	Parts.	Parts.	Parts.	Parts.
31	91717	92399	93052	93677	94273	94841
32	29	92410	62	87	83	50
33	40	21	73	97	93	60
34	52	32	84	93707	94302	69
35	91763	43	94	18	12	94878
36	75	92454	93105	28	22	87
37	87	65	16	30	31	96
38	98	76	26	93748	41	94905
39	91810	87	37	68	94351	15
40	21	28	93147	68	60	24
41	33	92509	58	78	70	33
42	44	20	69	88	80	42
43	91856	32	79	98	89	51
44	67	43	90	93809	99	94960
45	79	92554	93200	19	94408	69
46	90	65	11	29	18	79
47	91902	76	21	39	28	88
48	13	87	32	93849	37	97
49	24	98	93242	59	47	95006
50	36	92609	53	69	94456	15
51	91947	20	63	79	66	42
52	59	30	74	89	75	33
53	70	41	84	99	86	42
54	82	92652	95	93909	94	51
55	39	63	93305	19	94504	95060
56	92004	74	19	29	13	69
57	16	85	26	39	23	78
58	27	96	37	93949	32	87
59	39	92707	47	59	42	96
60	92050	18	93358	69	94551	95105

D M	72 *Parts*	73 *Parts*	74 *Parts*	75 *Parts*	76 *Parts*	77 *Parts*
1	95114	95638	96134	96600	97036	97443
2	23	47	42	07	43	50
3	32	55	50	15	50	96
4	41	64	58	22	75	63
5	50	95672	66	30	64	69
6	95159	81	74	37	97071	76
7	68	89	82	45	78	82
8	77	98	90	52	85	89
9	86	95706	98	60	92	95
10	95	15	96205	67	99	97502
11	95204	23	13	74	97106	08
12	12	31	21	82	13	14
13	21	40	29	89	20	21
14	30	95748	37	97	27	27
15	39	57	96145	96704	34	97534
16	95248	65	53	11	97141	40
17	57	73	61	19	48	47
18	66	95782	69	26	54	53
19	74	90	96277	34	61	59
20	83	98	84	96741	97168	97566
21	92	95807	92	48	75	72
22	95301	15	96200	56	82	78
23	10	23	08	63	89	85
24	19	32	16	70	96	91
25	27	40	24	96778	97202	98
26	36	95848	96331	85	09	97604
27	45	57	39	92	16	10
28	54	65	48	96800	23	16
29	62	73	55	07	30	23
30	95371	95881	96363	14	97236	97629